REPORT RESUMES

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ARTIFICIAL LIGHTING FOR MODERN SCHOOLS, A GUIDE FOR ADMINISTRATIVE USE.

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KANSAS STATE DEPT. OF PUBLIC INSTR., TOPEKA

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THE DEVELOPMENT OF GOOD VISUAL ENVIRONMENT AND ECONOMICALLY FEASIBLE LIGHTING INSTALLATIONS IN SCHOOLS IS DISCUSSED IN THIS GUIDE. EIGHTY PERCENT OF ALL SCHOOL LEARNING IS GAINED THROUGH THE EYES AS ESTIMATED BY THE U.S. OFFICE OF EDUCATION. GOOD SCHOOL LIGHTING IS COMFORTABLE, GLAREFREE AND ADEQUATE FOR THE VISUAL TASK. EYE STRAIN AND UNNECESSARY FATIGUE AS A RESULT OF POOR VISUAL CONDITIONS AFFECT LEARNING. SATISFACTORY LIGHTING IS MORE THAN PROVIDING RECOMMENDED LEVELS WHERE THEY ARE NEEDED. CONSIDERATION MUST ALSO BE GIVEN TO THE QUALITY OF LIGHT PROVIDING ADEQUATE AND COMFORTABLE SEEING CONDITIONS FOR EVERY TYPE OF SCHOOL ACTIVITY. FOUR FACTORS THAT AFFECT VISION ARE--(1) SIZE, (2) CONTRAST, (3) TIME, AND (4) BRIGHTNESS. OTHER TOPICS DISCUSSED ARE--(1) THE VISUAL ENVIRONMENT, (2) TRENDS IN NATURAL LIGHTING, (3) LIGHT AND INTERIOR FINISHES OF CEILINGS, WALLS, FLOORS, CHALKBOARDS, TRIM AND FURNITURE, (4) BRIGHTNESS DIFFERENCES, (5) PRINCIPLES OF SCHOOL LIGHTING, (6) BRIGHTNESS, (7) LEVELS OF ILLUMINATION, (8) SELECTING LIGHTING FIXTURES, AND (9) LIGHTING COSTS, SWITCHES, OUTLETS, MAINTENANCE AND SURVEYS. IT IS HIGHLY RECOMMENDED THAT SCHOOL BOARDS AND ADMINISTRATORS SEEK THE ASSISTANCE AND SERVICES OF TRAINED AND REGISTERED ARCHITECTS OR LIGHTING ENGINEERS TO DESIGN AND PLAN ANY MAJOR SCHOOL RELIGHTING PROGRAM. (RK)

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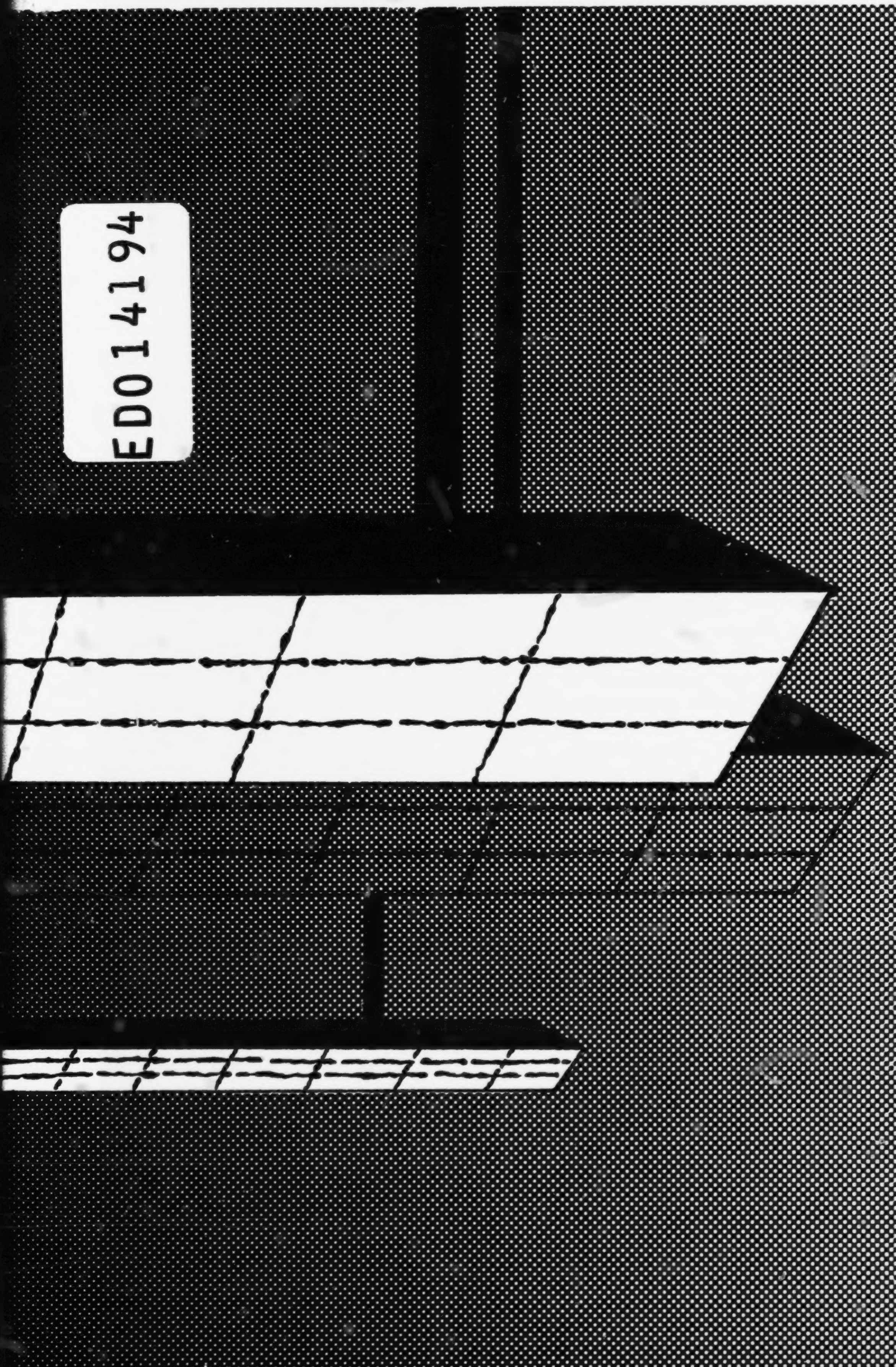

ARTIFICIAL LIGHTING FOR MODERN SCHOOLS

Issued by Adel F. Throckmorton · State Superintendent of Public Instruction · Kansas · 1960

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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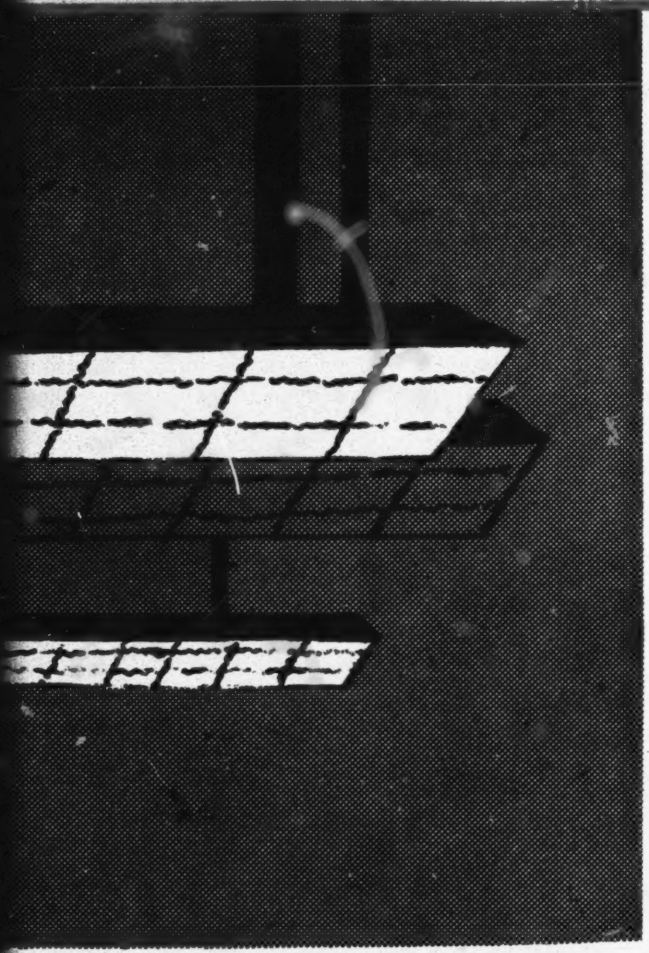

ARTIFICIAL LIGHTING FOR MODERN SCHOOLS

A Guide for Administrative Use

Prepared by
School Facilities Section
George W. Reida
Director

1960

EF 000 002

Introduction

This bulletin is designed to serve as a guide to the development of good visual environment in schools. In the opinion of the authors the recommendations stated herein will result in better lighting installations that are economically feasible for Kansas schools.

It is hoped the guide will be of assistance to architects, engineers, school officials, and others interested in school lighting. It is not intended that this bulletin be substituted for professional assistance but rather that it point out the importance of adequate lighting.

The material in this bulletin was reviewed and endorsed by the Kansas Chapter of the American Institute of Architects and by the governing body of the American Registered Architects of Kansas.

The State Board of Education has approved this publication for use in Kansas schools.

Adel F. Throckmorton
State Superintendent
of Public Instruction

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Appreciation is extended to the Interdepartmental Committee, composed of staff members of the State Department of Public Instruction and the State Board of Health, for their critical appraisal and assistance.

We are especially grateful to Neil J. Thompson, Lighting Specialist, Kansas Power and Light Company, Topeka, and Mr. C. B. Weeks, Commercial Sales Manager, Kansas Gas and Electric Company, Wichita, for their invaluable assistance in providing sketches of lighting fixtures, outlining specification, and developing Tables VI and VII on lighting costs.

We wish to thank John R. Newcomb, a fine arts student in the University of Kansas, Lawrence, for preparing the cover for this bulletin.

"There is a consumption of a quarter of the bodily energy in the processes of seeing. When vision is normal, the ease of seeing is controlled almost entirely by sufficient and proper lighting. However, when the illumination is improper or inadequate, and when the vision is poor, then the consumption of bodily energy is increased..."

--Dr. Charles Sheard
The American Journal of Optometry, July 1936

Good School Lighting

"Eighty per cent of all school learning is gained through the eyes." This estimate is made by the U. S. Office of Education.

Although it has long been known that most learning involves the visual processes, only in recent years has the need for good school lighting in schoolrooms received the attention which it deserves.

What is Good School Lighting?

Good school lighting, in simple terms, is comfortable, glare-free and adequate for the visual task. During school hours the students are required to use their eyes constantly since children learn by seeing and doing. Poor visual conditions cause eye strain and unnecessary fatigue, thereby affecting learning. As pointed out by the late Dr. Charles Sheard, "The marvelous flexibility of the eye has its price in bodily fatigue — not just headaches or burning eyelids, but exhaustion."

Satisfactory lighting is no longer only a matter of delivering the recommended levels of lighting where they are needed. Of equal, or perhaps even greater importance, is the consideration of the quality of lighting providing adequate and comfortable seeing conditions for every type of school activity.

Good school lighting is a highly technical matter requiring the guidance of trained lighting specialists. However, the science of seeing may be described briefly by enumerating four factors that affect vision:

Size —the larger the seeing task the more easily and quickly it is seen.

Contrast—black thread on white material is seen more quickly and easily than on black material. Good black print on white paper is easier to read than faded mimeographed print. Contrast is extremely important and school administrators should be aware of this fact in making their choice of textbooks, paper, pencils, and duplicating machines. Visibility may be improved by color combinations and contrasts necessary for comfortable vision, i. e., proper reflectance values.

Time—the time necessary to see an object is influenced by the brightness, the size, and the sharpness of the object.

Brightness—of these four factors, size and contrast frequently are not subject to immediate change, and the ability to see the task quickly and easily depends on adequate illumination on the desk tops, chalkboards, drafting tables, and other places where children work.

Terminology

LIGHT is the essential condition of vision, an emanation from a light-giving body. To see, there must be some degree of light present, but the ability to see comfortably and efficiently does not necessarily increase in direct ratio to the quantity of light available.

LIGHTING is developed from some source of light energy. Seeing is the visual response of the organism to the light environment. Thus, good lighting is determined by the degree of intelligence used in the application of light for a specific task, and the task's relationship to the total visual environment.

FOOT-CANDLE is a unit of illumination produced as a surface, all points of which are at a distance of one foot from a uniform point source of one candle. The unit of light quantity is measured with a foot-candle meter to determine the amount of light falling on a surface.

REFLECTION FACTOR might be expressed as the percentage of the total amount of light falling upon a surface which is reflected by that surface. This reflected light produces brightness. White has nearly a 100 per cent reflection factor, whereas black has nearly a zero per cent reflection factor. A surface with a 50 per cent reflection factor reflects half the light to the eye and absorbs half the light.

BRIGHTNESS is the luminous intensity of any surface. Brightness of a source of light, such as an electric lamp, is usually measured as candles per square inch. Brightness may be created by either reflection or direct transmission of light.

FOOTLAMBERT is the unit used to measure the brightness of other surfaces, and is the product of the output of a light source and the reflection characteristics of surfaces which the light strikes. Foot-candles times reflection factor equals footlamberts. Candles per square inch are easily transposed into footlambert, since a brightness of one candle per square inch is equal to 452 footlamberts.

About the year 1954 Karl Fruend invented a device called a Spectra Brightness Spot Meter. This meter provides a simple method of measuring brightness of other surfaces. The result is a reading in footlamberts, measuring conditions of the surface, not the source.

BRIGHTNESS-RATIOS are the ratios of the brightness of the visual task as compared to that of the surrounding field of vision.

BRIGHTNESS-DIFFERENCE is a term used to express the difference in brightness between any surfaces anywhere within the total visual field. Brightness-difference can be measured by comparing footlamberts.

BRIGHTNESS-BALANCE is the ultimate in producing visual comfort and efficiency. To achieve an acceptable brightness-balance, the brightness-difference within the task is kept high while the brightness-difference between the task and the surrounding areas are kept low.

A LUMINAIRE is a lighting fixture, either fluorescent or incandescent.

TASK as used in this bulletin may be interpreted to include any visual activity which may be encountered in a classroom, e. g., a book, handwritten material, a chalkboard with symbols, laboratory apparatus, art work on easel, exhibits on tackboard, etc. The task may require the student to face in any direction, and may be on either a horizontal or a vertical plane.

Visual Environment

Present day educational practices accept informal seating in the classroom. Thus, the visual field must be recognized as encompassing all four walls, the floor, and the ceiling. Light will need to be directed where it is needed on the task. The brightness of the task should be sufficient for the most difficult assignment to be performed by the student.

Ample light should be provided so written materials on the chalkboard can be seen easily without glare from the back of the classroom. Often a special chalkboard light fixture is necessary to light the chalkboard properly, since even a high quantity or room lighting generally does not afford a good distribution of light on the chalkboard.

The basic problem in establishing and maintaining a satisfactory visual environment for classrooms is to create and maintain a proper balance of brightness between the reference task brightness, and all the high and low brightnesses of other surfaces visible from the reference point. In a properly lighted classroom, there should always be more light on the task than on the eye. Ideally, the task confronting the student should be at least as bright as the surrounding visual environment; slightly brighter is better.

Originally it was believed that the more light on the work, the better the seeing condition. Authorities agree that while the quantity of light is important, good seeing conditions are more dependent upon quality than on quantity. Quality lighting results when light is evenly distributed throughout the room, with glare sources eliminated and contrasts between bright and dark surfaces reduced to a minimum. It is especially important to eliminate glare and high contrast. These terms are commonly used to express the discomfort caused by a great difference in brightness between adjacent surfaces.

A pleasant, comfortable environment can generally promote a higher level of learning—children spend approximately nine months a year, five days a week, six hours a day in the classroom. Most of them spend at least the better part of twelve years in an academic environment. The classroom should be an invitation to the child. Adequate illumination creating a comfortable environment makes the learning process and the level of production higher.

TRENDS IN NATURAL LIGHTING

The role of daylighting in schoolroom illumination has changed radically over the years. The light source is dependent on the elevation and seasonal course of the sun, the condition of the sky, and the location of the rooms.

Available daylight should be used to advantage but without glare from objects, surfaces or clouds in direct sunlight. See Table III, page 14, which illustrates the seeing hazards of open skies and open lamps.

Some form of shielding should be provided against high exterior or sky brightness. This may be done with lightweight venetian blinds, set so as to reflect outside light toward the ceiling, but to cut off direct view of the sky. Slats may be adjusted horizontally for about two feet at the eye level to permit a "vision strip" to rest eye muscles after long periods of close work. Double-hung translucent shades may be installed and fitted in the window frame with shields to prevent light leaks.

Exterior light controls, such as fixed or movable baffles, may be employed to control excessive sky glare or direct sunlight. One very satisfactory device is an aluminum awning. Other methods include fixed vertical louvers, and large fiberglass diffusing screens of 60% light transmission set with the bottom edge against the window and tilted in 30 degrees at the top.

Light and Interior Finishes

In all lighting systems, some of the light reaches the work plane by being reflected from the walls and ceilings. In indirect lighting systems, all of the useful light is reflected from these surfaces before it reaches the work plane. It is apparent, therefore, that the efficiency with which the generated light is utilized may depend in large degree upon the reflectances of the room surfaces.

Light-toned walls, ceilings, floor surfaces, and furniture impart an air of cheerfulness and efficiency to any classroom. A general harmony of brightness in the room is good without too much contrast anywhere. To avoid monotony, small accent areas of darker colors may be used.

The reflection characteristic of all room surfaces has a bearing on the amount and kind of light diffused in the room. Some of the light falling upon a surface is absorbed and the rest reflected. The amount reflected is expressed in terms of per cent and is called reflectance factor.

CEILINGS. The ceilings should be a nonglossy or flat finish and as high in reflectance as possible to assure good illumination efficiency and to bring the ceiling brightness as close to that of the luminaire as possible. The ceilings should be white and have at least an 85 per cent reflectance factor. Acoustic plaster and nonperforated fiber boards when painted, especially with an oil base paint, may lose some of their acoustical qualities. If these materials are left unpainted, their light reflection factor may fall considerably below the 85 per cent recommended for good visual conditions.

WALLS. The reflectance of the walls should be high enough so that they reflect light back into the room efficiently, but just dark enough so that they are in suitable visual balance with the average or typical visual task in the room. The 50 to 70 per cent range accomplishes this and permits a wide range of cheerful and pleasing colors. The window walls usually receive no direct daylight and as a result they are in high brightness difference with the window areas. For this reason, they should be finished in the 75 to 80 per cent reflectance factor. The reflectance of a wall in front of which an instructor may stand should be in the lower end of the 50 to 70 per cent reflectance range.

FLOORS. Classroom floors should be as light as practical considerations permit. Natural finished light wood floors and light color tile floor materials may be obtained in reflectances up to approximately 50 per cent. Floor finishes should have from 20 to 50 per cent reflection factor. The practice of installing floors having highly contrasting checkerboard patterns of color should be avoided.

CHALKBOARDS. Chalkboards should strive to meet at least two brightness criteria. They should be light enough to blend in well with their background and dark enough so that chalk writing has sufficient contrast to assure good visibility. Colored boards should not exceed 20 per cent reflectance. The instructor's chalkboard should be provided with supplementary lighting to improve the brightness ratio between a chalkboard and its surrounding surfaces.

TRIM. The trim should be finished with a 30 to 60 per cent reflection factor paint. In a new building it is usually well to finish the trim in a natural wood finish. However, the trim may be of a different color from the walls but should retain about the same reflection factor values to avoid objectionable brightness-differences. For remodeling purposes good results may be obtained by painting the walls and trim the same color, perhaps a shade darker on the trim.

FURNITURE. Desk tops and other furniture occupy a substantial part of the visual field. Light finished birch or maple desk tops usually fall well within the indicated range of 35 to 50 per cent reflectance. Desk top surfaces should be nonglossy in order to avoid annoying and distracting reflections of windows or overhead light sources.

TABLE 1

RECOMMENDED REFLECTION FACTORS FOR CLASSROOM SURFACES*

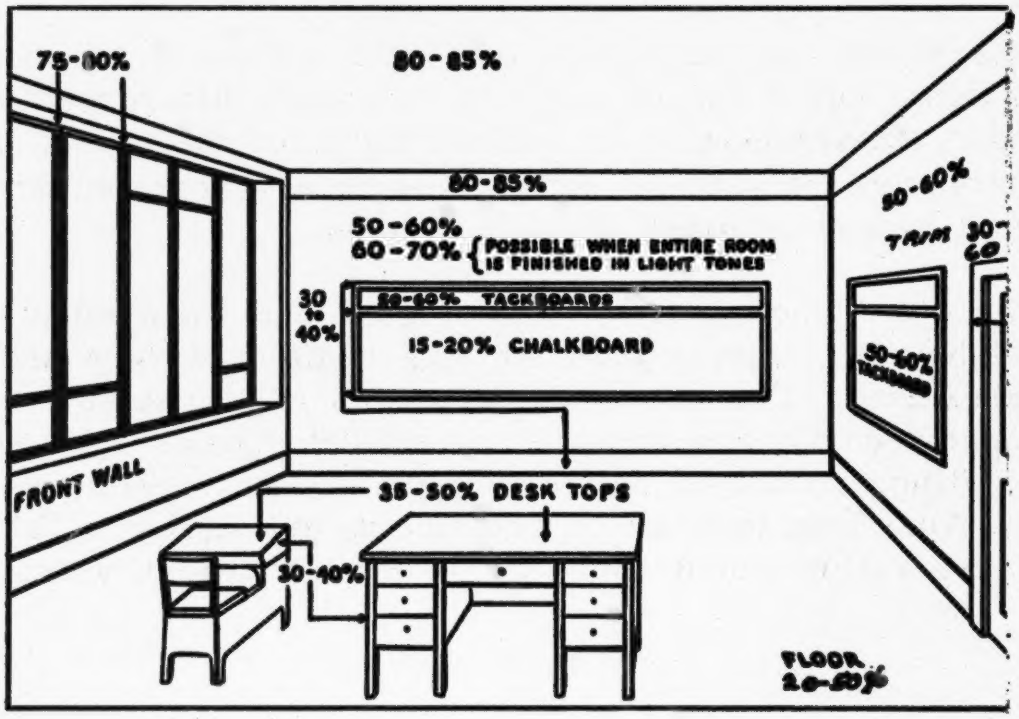
	Reflection Factors**
Ceilings (white or off white)	80-85%
Window Walls (pastel colors)	75-80%
Other Walls (pastel colors)	50-60%
Trim	30-60%
Desk and Equipment	35-50%
Floor	20-50%
Chalkboards	15-20%

*Recommendations as published by the Illuminating Engineering Society.

**Reflection factors of finishes are available from manufacturers of paint products.

ILLUSTRATION 1

RECOMMENDED REFLECTANCE PATTERN


75-80%
80-85%
80-85%
50-60%
60-70% {POSSIBLE WHEN ENTIRE ROOM IS FINISHED IN LIGHT TONES
30 to 40%
50-60% TACKBOARDS
15-20% CHALKBOARD
50-60%
TRIM 30-60
50-60% TACKBOARD
FRONT WALL
35-50% DESK TOPS
30-40%
FLOOR 20-50%

Surface finishes should be flat (diffuse) on all interior surfaces at eye level and above. Semigloss finishes are not recommended but are acceptable on surfaces below the eye level for areas where frequent cleaning is necessary. Desk tops should have a flat nonglossy finish. Within the above limits, walls may be finished in any colors which are aesthetically and psychologically suitable.

Brightness Differences

To achieve quality lighting in a classroom is a matter of balance of brightness areas. Eye fatigue in pupils is usually caused by a great variation in brightness areas.

There are three areas of brightness to which a pupil must adjust:

> the brightness of the task itself (e.g., the page in a book),
>
> the brightness of the immediate surroundings of the task (e.g., the desk top), and
>
> the brightness of the entire peripheral field of vision (e.g., everything the eye sees in the field of view, upward, downward, and on both sides.)

The child's eye can adjust readily to changes in the quantity of light, but it cannot adjust to excessive differences which exist **simultaneously** in various parts of the visual field. **Excessive brightness differences in a classroom are the real causes of glare and eye fatigue.**

The eyes function most comfortably and efficiently when brightness ratios within the entire field of view are not excessive. The minimum standards of brightness ratios suggested by American Standards Practices for School Lighting, published by the Illuminating Engineering Society and American Institute of Architects, are shown in Table II. These ratios would apply to the visual pattern within the classroom regardless of the source of light and also to the outdoor surfaces which are visible from the room.

TABLE II

RECOMMENDATIONS FOR LIMITS OF BRIGHTNESS RATIOS IN CLASSROOMS [1]

		Ratio
a.	Between the seeing task and immediately adjacent surfaces, such as between task and desk tops.*	1 to 1/3
b.	Between the task and the more remote darker surfaces, such as between task and floor.	1 to 1/10
c.	Between the task and the more remote lighter surfaces, such as between task and ceiling.**	1 to 10
d.	Between luminaires or windows and surfaces adjacent to them in the visual fields.	20 to 1
e.	Anywhere within the normal field of view.	40 to 1

* Chalkboard and some art and shop tasks are illustrations of instances where the reverse ratio of 1 to 3 may apply.

** These ratios apply for areas of appreciable size as measured by the solid visual angle subtended at the eye. Luminous areas on luminaires are generally small in size in this respect. For the brightness limitation of luminaires, see Table V.

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[1] IES Lighting Handbook, Third Edition, Page 11-9. Published by the Illuminating Engineering Society, 1860 Broadway, New York 23, New York.

While brightness contrast between the task and its visual background is desirable, varying with size of detail to be observed, brightness of any surface in the surrounding field should not be greater than ten times that of a task nor less than one-third that of a task.

Principles of School Lighting [2]

1. Under ideal conditions for visual comfort and efficiency, the brightness of the task should be equal to or slightly greater than the brightness of the surrounding visual environment.

2. In a classroom, the brightness of any surface viewed from any normal standing or sitting position should not be excessively greater than the brightness of the visual task. As the high brightness of surfaces in the visual field approaches the brightness of the task, visual comfort and efficiency increase. Present research indicates that for best lighting, the highest acceptable brightness of any surface in the visual field should not be greater than ten times the brightness of the task.

3. In a classroom, the brightness of any surface viewed from any normal standing or sitting position should not be excessively lower than the brightness of the visual task. As the low brightness of surfaces in the field approaches the brightness of the task, visual comfort and efficiency increase. Present research indicates that for best lighting the lowest acceptable brightness of any surface in the visual field should not be less than one-third the brightness of the task.

4. The brightness of surfaces immediately adjacent to the visual task is more critical in terms of visual comfort and efficiency than that of more remote surfaces in the visual surroundings. These adjacent surfaces have lower acceptable

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[2] GUIDE FOR PLANNING SCHOOL PLANTS, 1958 EDITION. PUBLISHED BY NATIONAL COUNCIL ON SCHOOLHOUSE CONSTRUCTION. PAGES 219-220.

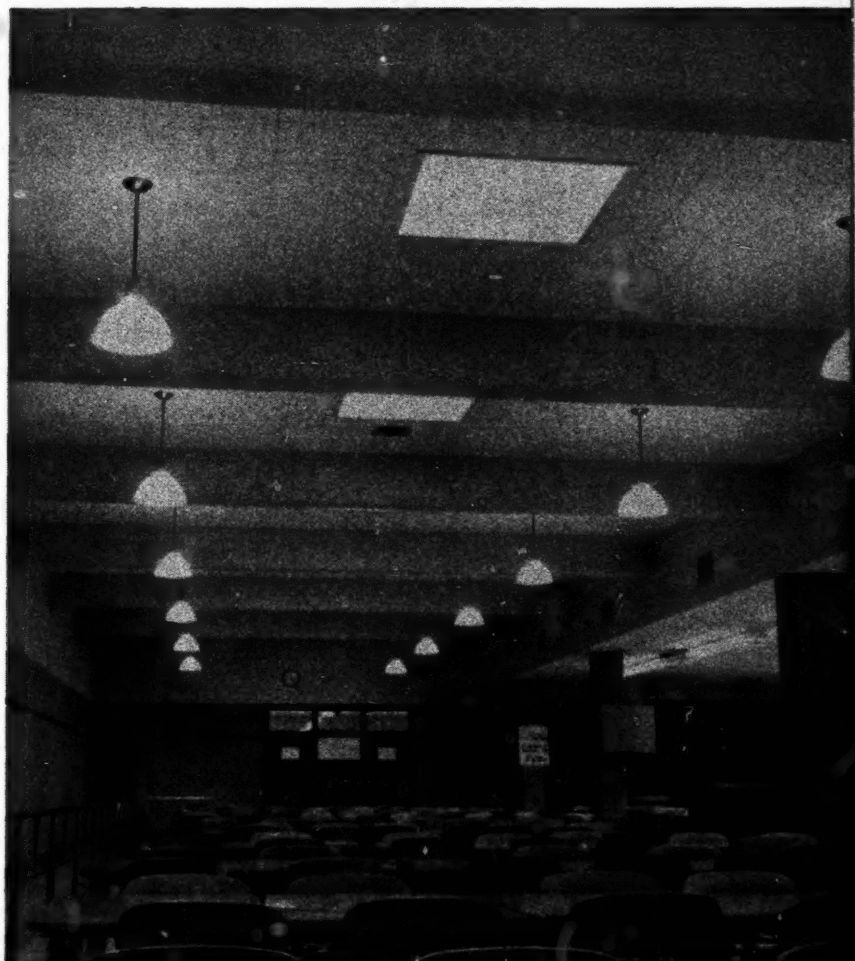
brightness limits than surfaces further removed from the task. Present research indicates that surfaces immediately adjacent to the visual task should not exceed three times the brightness of the task.

5. The brightness-difference between adjacent surfaces in the visual surroundings should be reduced to an acceptable minimum.

6. The characteristics of any lighting system should be such that direct and reflected glare are not objectionable. If the brightness differences produced by a lighting system are held within the limits stated in Principles 2, 3, and 4, direct and reflected glare will not be objectionable.

7. Daylight and electric light systems should conform to the same brightness and brightness-difference principles, and both systems should be coordinated in design to assure the effective contribution of both.

8. Any lighting system should be designed in such a manner that it will contribute to a cheerful, friendly and aesthetically pleasing classroom environment.



THIS LARGE DINING ROOM ILLUSTRATES THE USE OF MORE THAN ONE TYPE OF LIGHT FIXTURE.

Typical Brightness

To illustrate the seeing hazards of open skies and open lamps, the following table gives some approximate readings on self-luminous sources. The readings indicate that light controls are necessary to achieve proper brightness patterns.

TABLE III

ILLUSTRATIONS OF BRIGHTNESS

	Approximate Brightness in Footlamberts
Clear sky	1, 000
*Hazy sky	1, 000-6, 000
*White clouds	3, 000-8, 000
*Sunlight on white buildings	5, 000-8, 000
Sunlight on trees	75-1, 000
Bare 200-watt inside frosted filament lamp—brightest spot	65, 000
Opal glass enclosing globe fixture	800-1, 200
**Bare T12 fluorescent lamp (430MA)	1, 900
**Bare T12 fluroescent lamp (200MA)	1, 100
**Bare 40-watt T17 fluorescent lamp	1, 100
Louvered fluorescent fixture	150-1, 200
Luminous indirect fluorescent fixture	175
White ceiling above indirect incandescent fixture	
500-watt—30 inches from ceiling	110-130
500-watt—42 inches from ceiling	60-80
750-watt—48 inches from ceiling	95-120
Average task—50 f. c. on 70% R. F.	35
Desk top—50 f. c. on 50% R. F.	25
Floor—30 f. c. on 30% R. F.	9
Tackboard—50 f. c. on 50% R. F.	25
Chalkboard—50 f. c. on 30% R. F.	15
Walls—40 f. c. to 200 f. c. on 75% R. F.	30-150
Green grass—6, 000 f. c. on 20% R. F.	1, 200
Bare dry ground—6, 000 f. c. on 25% R. F.	1, 500
Fresh snow—6, 000 f. c. on 75% R. F.	4, 500
Directional glass block	up to 2, 800

*The brightness of clear sky is less because there is nothing in the sky to reflect the direct rays to the eye.

**Fluorescent lamps must be shielded from normal viewing angle to come under acceptable maximum brightness.

Levels of Illumination

After more than ten years of basic research, an Ohio State Scientist, H. Richard Blackwell, who is both a psychologist and a physiologist in optics, has developed a quantitative method for determining the illumination levels required for adequate performance of specific visual tasks. His material has been presented before the Joint Task Committee on School Lighting, consisting of representatives of the American Institute of Architects, the National Council on Schoolhouse Construction, and the Illuminating Engineering Society. The Joint Task Committee decided that a series of recommended values, according to the tasks, could be published in the Third Edition of the Illuminating Engineering Society Lighting Handbook. These levels follow closely the measurements made by Dr. Blackwell on tasks related to school work.

The foot-candle levels of illumination for school classroom tasks, rather than areas, approved by the School Lighting Committee of the Illuminating Engineering Society, and which appear in the 1959 Edition of the I. E. S. Lighting Handbook, Page 9-82, are as follows:

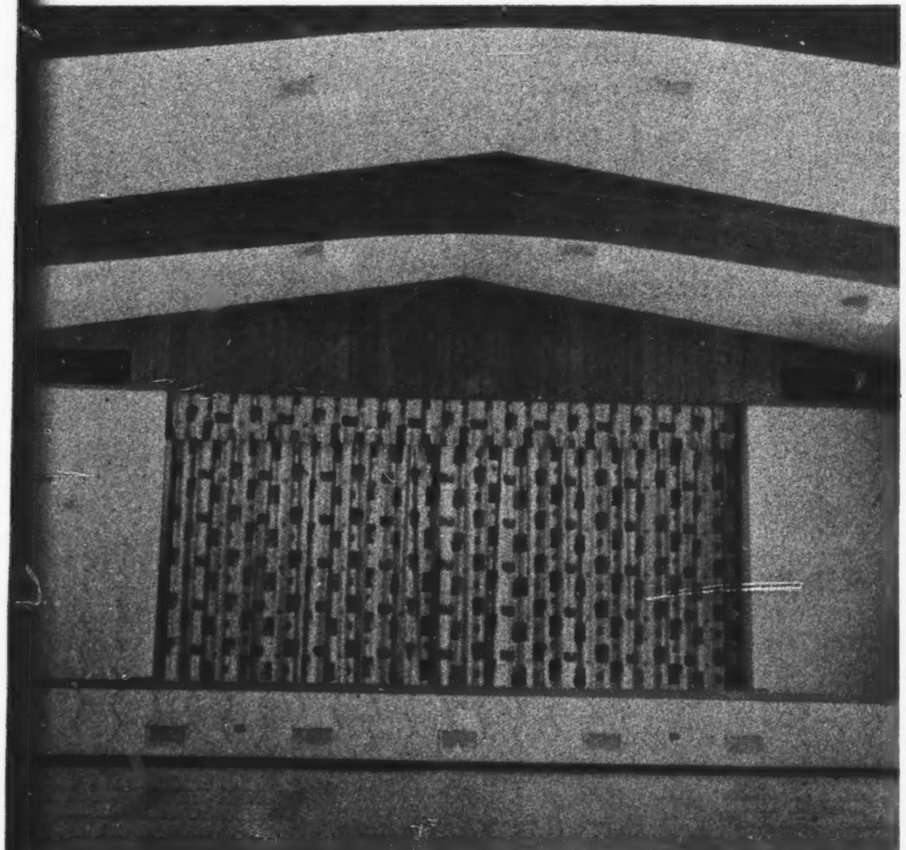
Tasks	Foot-candles on Tasks*
Reading printed material	30
Reading pencil writing	70
Spirit duplicated material	
Good	30
Poor	100
Drafting, benchwork	100**
Lip reading, chalkboards, sewing	150**

*Minimum on the task at any time.

**Obtained with a combination of general lighting plus specialized supplementary lighting. Care should be taken to keep within the recommended brightness ratios. These seeing tasks generally involve the discrimination of fine detail for long periods of time under conditions of poor contrast. To provide the required illumination, a combination of the general lighting indicated, plus specialized supplementary lighting is necessary. The design and installation of the combination system must not only provide a sufficient amount of light, but also the proper direction of light, diffusion, and eye protection. As far as possible, it should eliminate direct and reflected glare as well as objectionable shadows.

For persons with standard vision, a 30 to 50 foot-candle range on the reference task was recommended by the National Council on Schoolhouse Construction in their 1958 Edition "Guide for Planning School Plants." This recommendation was made prior to Dr. Blackwell's published findings.

The National Council pointed out that approximately 20 per cent of the pupils in elementary schools have substandard vision. People with substandard vision benefit to a greater degree from improved illumination than do people with standard vision. Therefore, serious consideration should be given to the desirability of providing illumination levels in excess of the foot-candle range stated above.



THESE PROTECTED LIGHT FIXTURES ARE SUITABLE TO THE MANY ACTIVITIES COMMON TO A MULTI-PURPOSE ROOM.

TABLE IV

LIGHT INTENSITIES FOR KANSAS SCHOOLS

	Recommended Foot-candle Levels*	Minimum Foot-candle Levels**
Classrooms, office, laboratories	70	30
Drafting rooms	100***	50
Sewing rooms	150***	50
Sight-saving rooms	150***	50
Art rooms	100***	50
Shop rooms	100***	50
Study halls	70	30
Libraries	70	30
Cafeterias (not for study)	20	20
Cafeteria kitchens	30	30
Gymnasium, exhibitions, matches	50	30
Multi-purpose rooms	35	30
Swimming pools	30	30
Auditoriums (not for study)	20	15
Corridors and stairways	20	15
Locker rooms, team rooms, etc.	20	20
Entrances, porticos, vestibules, etc.	15	15
Walks and parking areas.	1/2	1/2

*The quality aspects of lighting embrace all factors which contribute to visual comfort in the seeing process. It becomes imperative to provide a good quality of lighting, because as higher levels are used in accordance with the recommendations for some of the tasks, it is especially vital that a balanced brightness environment be preserved for utilization of these higher values on the task. If the brightness ratios are exceeded, or if the luminaires become too bright, there will be deleterious effects which will reduce the visibility from that measured by Dr. Blackwell under no-glare conditions.

**Required for minimum accreditation purposes.

***On the Task (see previous page).

Selecting Lighting Fixtures

Over the years the cost of electricity has constantly declined. With this has come the installation of additional and better fixtures to improve seeing conditions in the classroom.

"The following points should be evaluated when selecting an electric lighting system.

1. The lighting should produce a uniform distribution of shadow-free and glare-free illumination with the intensities necessary to maintain an acceptable brightness-balance between the task and other surfaces within the total vision environment.

2. Consideration should be given to probable deterioration of efficiency in service under prevailing conditions of school operation and maintenance.

3. Lighting fixtures should not produce a surface brightness on the fixture or on the ceiling that exceeds ten times the task brightness."[3]

The basic selection of lighting fixtures assumes a greater prominence than ever before as the need for higher and higher levels of illumination meet "head-on" the economy of designing for lower and lower ceilings. This is pointed out by Jack Bouse in his article, Selecting Lighting Fixtures, The American School Board Journal, January, 1959.

In selecting a lighting fixture, be sure that it:

Performs the required task.

Is substantially constructed and finished for low maintenance.

Has a ballast which meets the proper ambient temperature standards.

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3. GUIDE FOR PLANNING SCHOOL PLANTS, 1958 EDITION. PUBLISHED BY NATIONAL COUNCIL ON SCHOOLHOUSE CONSTRUCTION, PAGE 225.

Provides for heat dissipation by use of vents, baffles, etc.

Is manufactured by a reputable firm which will be able to replace and reproduce the product.

Is priced within the budget framework of the school being built.

Brightness

The brightnesses in Table V are recommended as maximum average values both crosswise and lengthwise of the luminaire. Observance of these maximum values will limit glare from luminaires under normal circumstances of installation and room decoration.

TABLE V

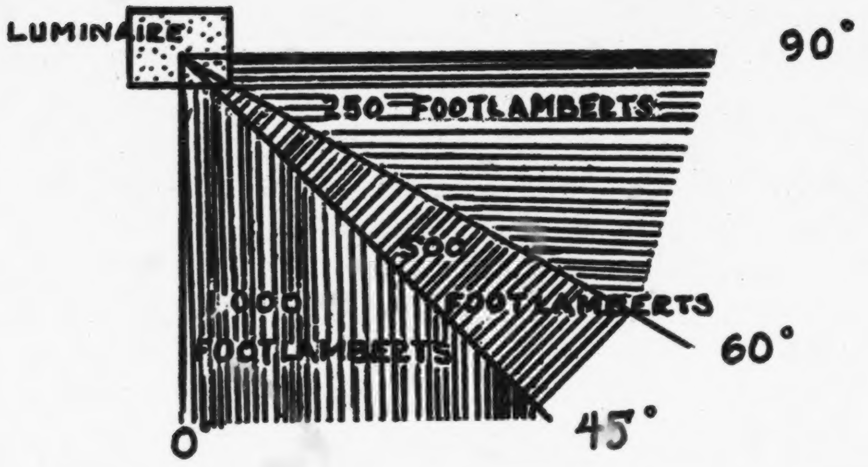
MAXIMUM FOOTLAMBERTS RECOMMENDED FOR LUMINAIRE

Zone (0° is directly beneath luminaire)	Candle Power /Sq. In.	Acceptable Average Brightness Limits* (Footlamberts)
60° - 90°	.5	250
45° - 60°	1.1	500
0° - 45°	2.2	1,000

*Average brightness of the brighest one-inch square. The ratio of maximum to average brightness at any viewing angle shall not be greater than 5 to 1.

Most manufacturers of quality lighting equipment include the above information for their fixtures in their catalogue data sheets.

ILLUSTRATION 2



Higher values than these may be acceptable in installations where care is taken to use light colors and matte finishes in the lower as well as the upper parts of the room, and where the bright areas of the luminaires are small, as is the case with direct incandescent luminaires. In these cases, an accepted method of comfort evaluation should be used to verify that the installation will be comfortable. (Guth BCD, Harrison-Meeker VCI or Logan-Lange VCF.)

A BRIEF COMPARISON OF INCANDESCENT AND FLUORESCENT LIGHT

The intrinsic color of incandescent light is generally yellow or warm, while that of fluorescent is blue or cool (however, phosphorus and glass housing can alter the source in tone.) Incandescent in a spotlight can be hard, concentrated, and demanding; or used in shaded lamps, it can be soft, a pool of friendly, mellow light.

Fluorescent is a bland bath of light, a practical imitation of daylight. Fluorescent fixtures consume less power than incandescent for the quantity of light produced and last longer, but are usually more expensive to install and maintain. For most areas the standard white color fluorescent lamp is satisfactory. Deluxe white color lamps are preferable for art rooms, home economics rooms, sewing rooms, cafeterias and other similar areas. These lamps are approximately 25% less efficient than standard lamps. When deluxe lamps are considered, the designer should compensate for the lower lamp efficiency in the original planning.

LUMINAIRE MOUNTINGS

Luminous fixtures should be mounted properly to achieve best results. Lighting engineers will need to determine lighting requirements for a classroom before making a lighting layout design. The lighting system should be designed and fixtures carefully selected to correlate with the goals previously established for a good visual environment.

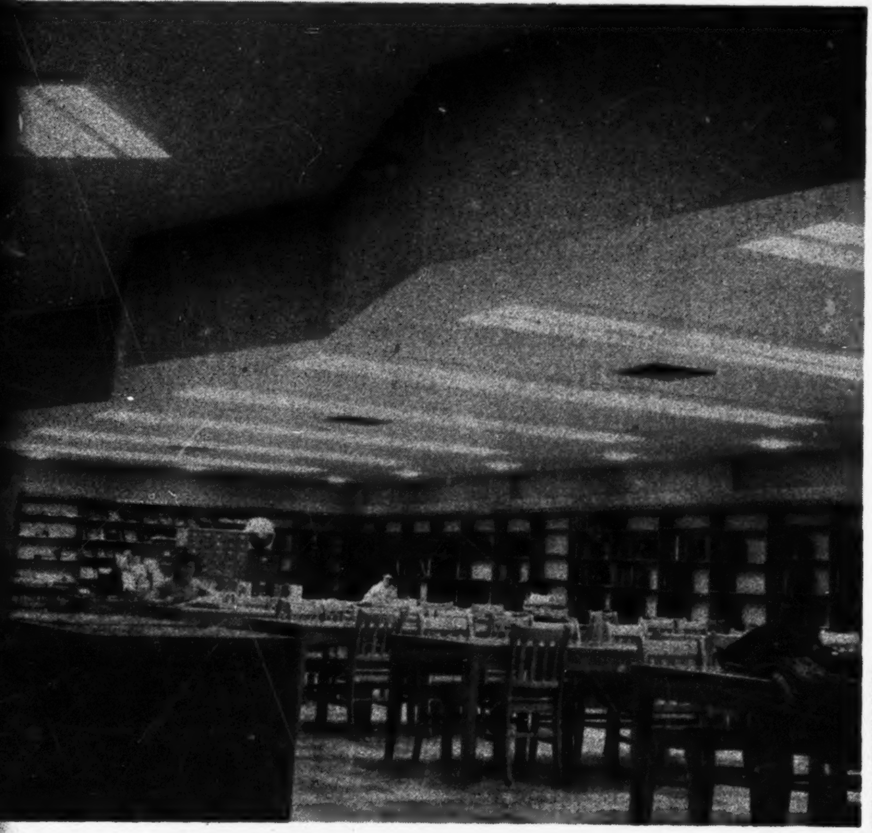
In low-ceiling classrooms, the fixtures must necessarily be mounted close to, or in contact with the ceilings. As the ceiling heights are increased, proper adjustments must be made in order to achieve desired results. Usually in most regular classrooms with ceiling heights of 10 feet or more, it is well to hang luminaires at 9 feet above floor level.

Fluorescent fixtures, as illustrated on pages 23, 25, and 27, should use two-lamp rapid start or slimline ballast certified and approved by Certified Ballast Manufacturers and Electrical Testing Laboratories. Lamp holders of good quality should be secured firmly in fixture to insure positive contact.

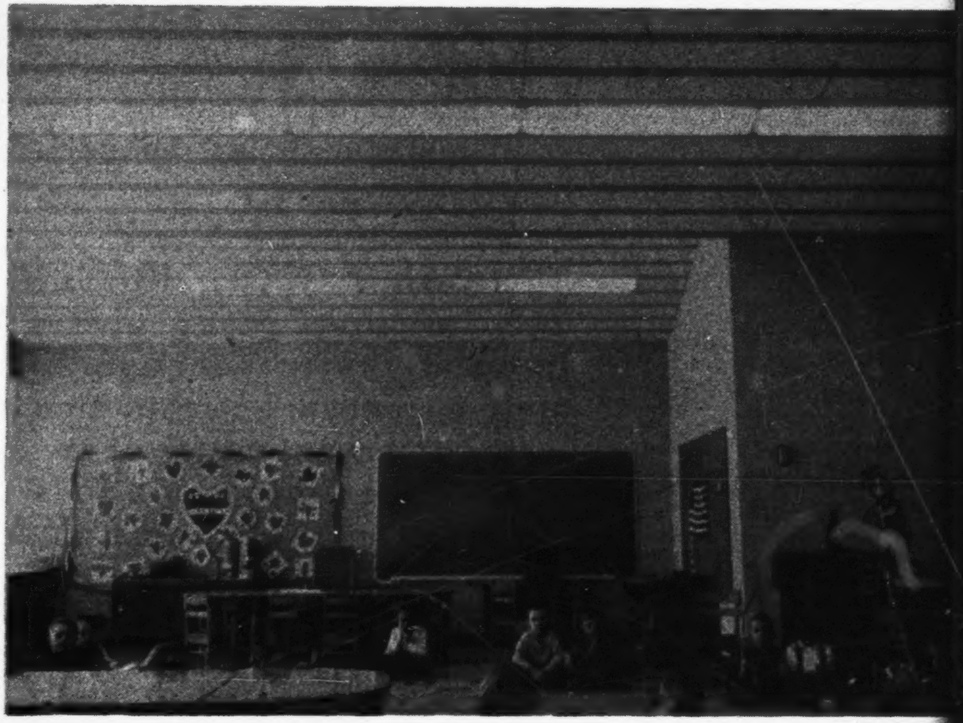
TYPICAL SCHOOL LIGHTING FIXTURES

The following pages give a brief description of the most frequently used electric lighting fixtures. The order of their appearance in this manual has nothing to do with popularity or acceptability of the fixtures. It must be noted that it would be impossible to show all fixtures manufactured; however, an attempt was made to show a sampling of typical fixtures. In selecting lighting fixtures, manufacturers' specifications should be carefully examined in order to provide for efficiency and brightness limits. Fixtures should not be chosen because of similarity in appearance to those illustrated in this manual, unless performance data will support the selection.

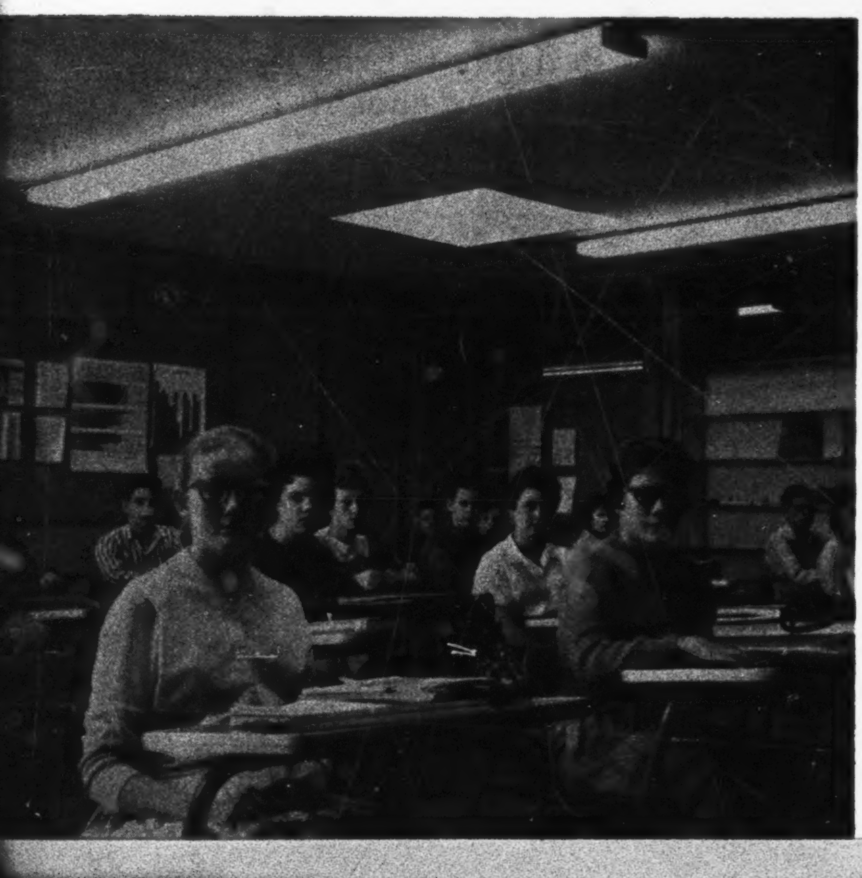
TWO TYPES OF SEMI-DIRECT LIGHT FIXTURES ARE COMBINED AND USED IN LIGHTING THIS LARGE ROOM.



ALL AREAS ARE WELL LIGHTED THROUGH THE UNUSUAL VARIED ARRANGEMENTS OF THE LIGHTING FIXTURES IN THIS LIBRARY.

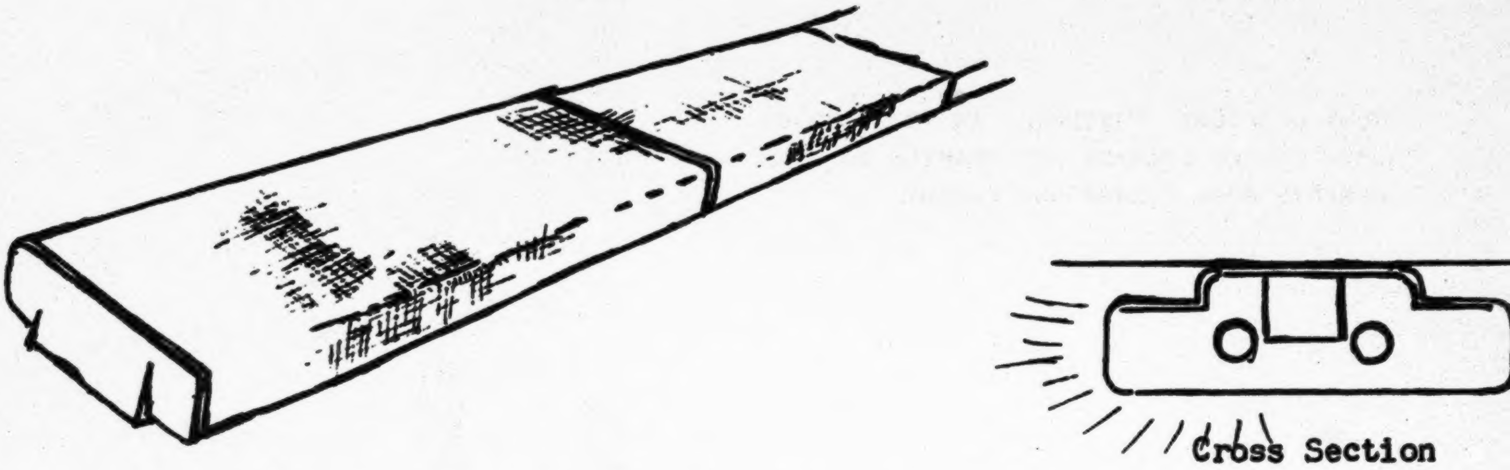


CONTINUOUS ROWS OF FIXTURES PROVIDE LIGHTING FOR MANY KINDERGARTEN PROJECTS.



THE DESK TOPS ARE WELL LIGHTED IN THIS JUNIOR HIGH SCHOOL CLASSROOM.

Figure No. 1



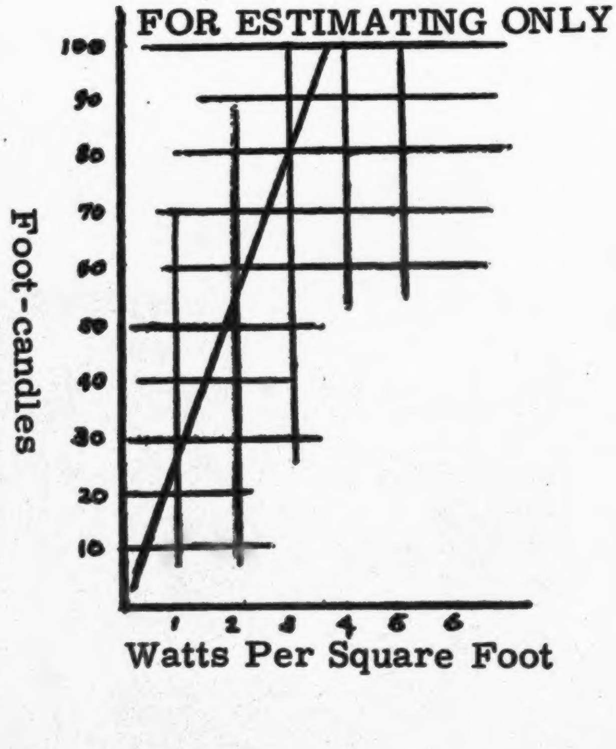
SEMI-DIRECT FLUORESCENT FIXTURE

Sixty to ninety per cent of the light is directed downward at angles below the horizontal. The foot-candles effective under this system at normal working planes are primarily a result of the light coming directly from the luminaire. The portion of the light directed to the ceiling results in a relatively small indirect component, the greatest value of which is that it brightens the ceiling area around the luminaire, with a resultant lowering of brightness contrasts.

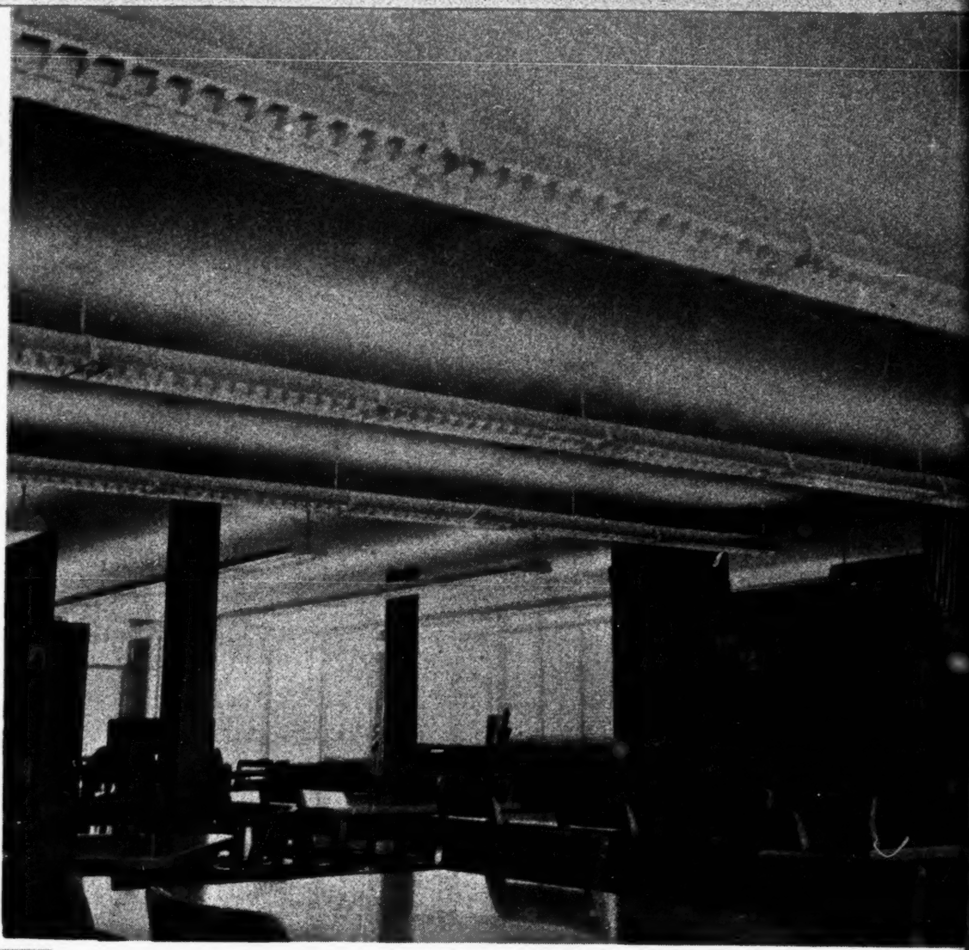
Brightness limitations set forth previously, in most cases, dictate a prismatic lens shield not to be confused with plain, frosted or opal glass, or plastic.

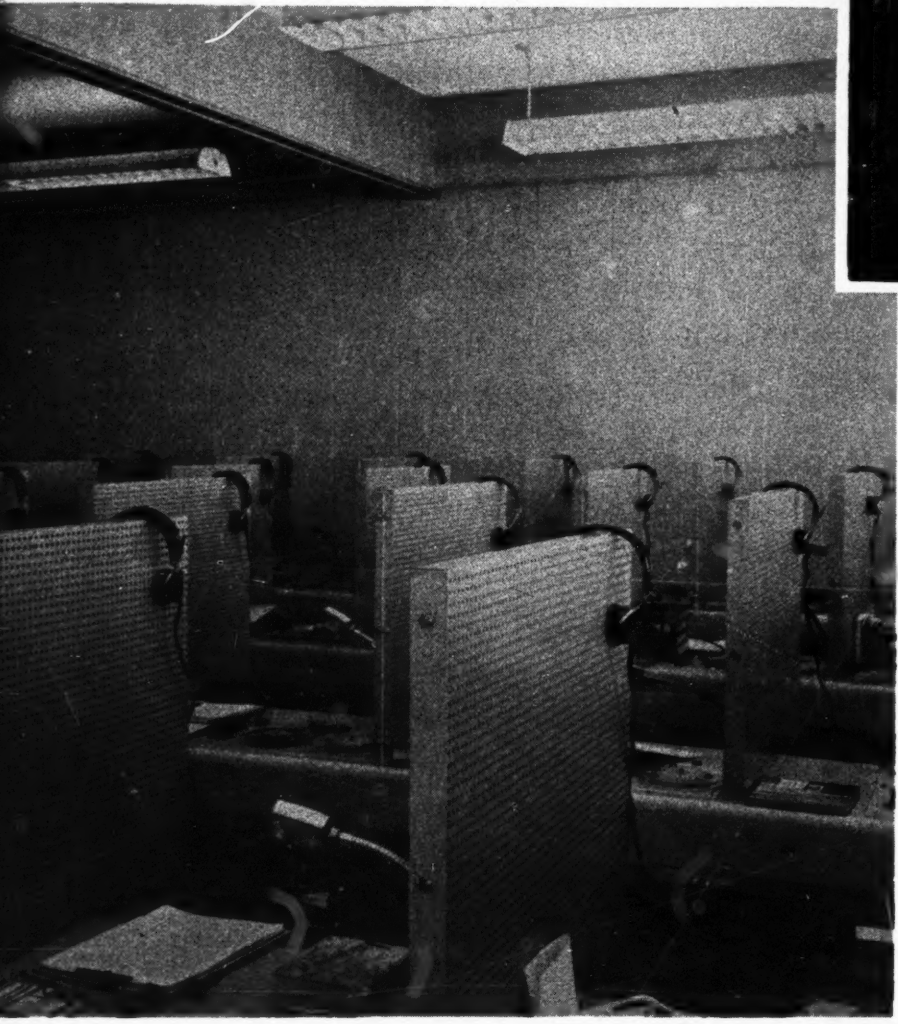
Fixtures should be mounted in continuous rows, either on surface or pendants. Optimum spacing between rows should not exceed 1.75 times the mounting height above the work plane. Spacing from wall to first row of fixtures should not exceed one-half the spacing of rows.

Fixture rows should run parallel to and not more than 4'0" from chalkboards unless supplementary chalkboard lighting is used.



ROWS OF LIGHT FIXTURES IN THIS SENIOR HIGH SCHOOL LIBRARY ARE ADAPTED TO THE GENERAL ROOM DESIGN AND LAYOUT.

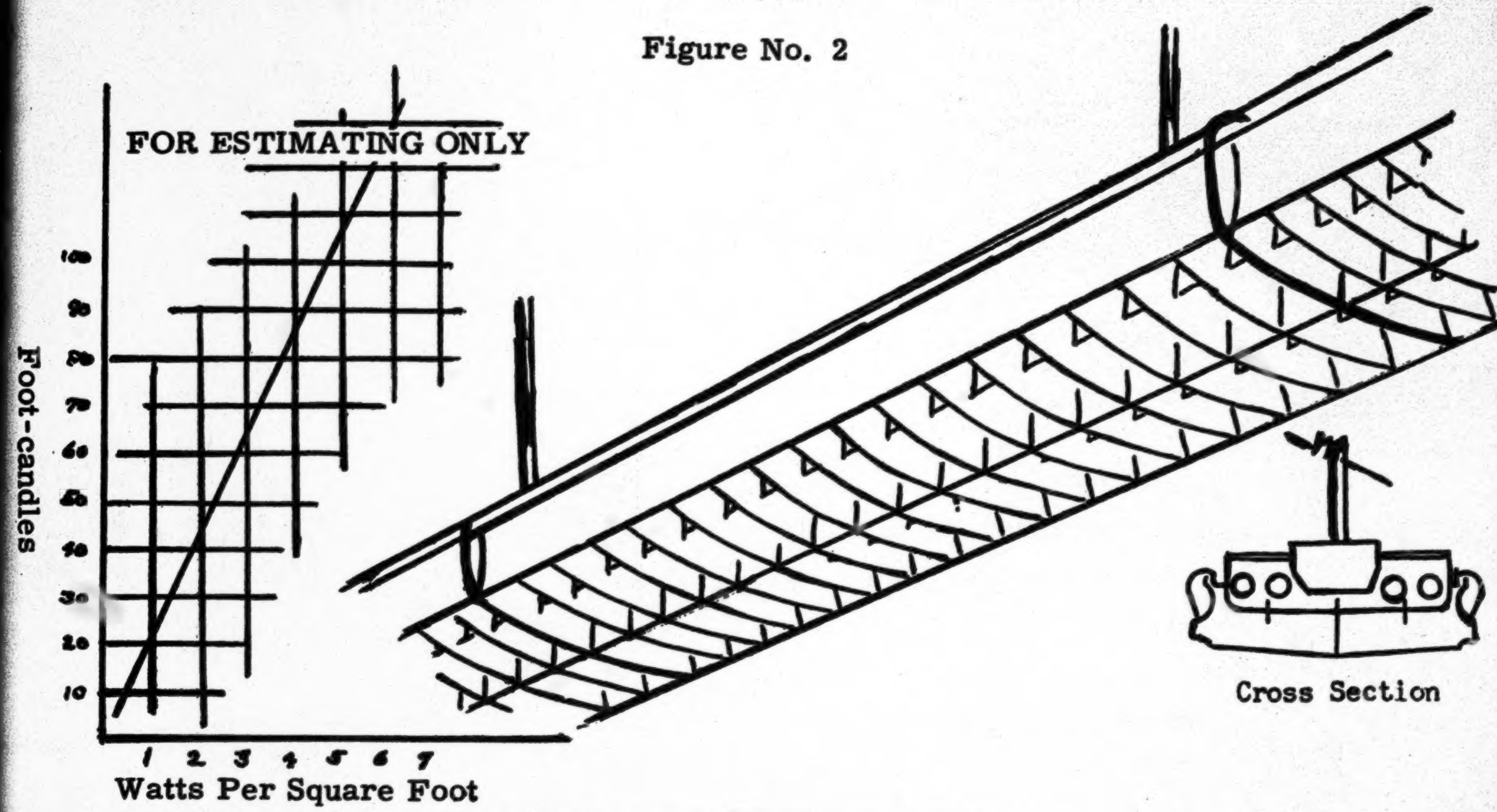




THIS LANGUAGE LABORATORY UTILIZES THE MOST MODERN ELECTRONIC DEVELOPMENTS.

THE FIXTURES IN THIS KINDERGARTEN ROOM ILLUSTRATE THE PROPER SUSPENSION DISTANCE FROM THE CEILING.

Figure No. 2

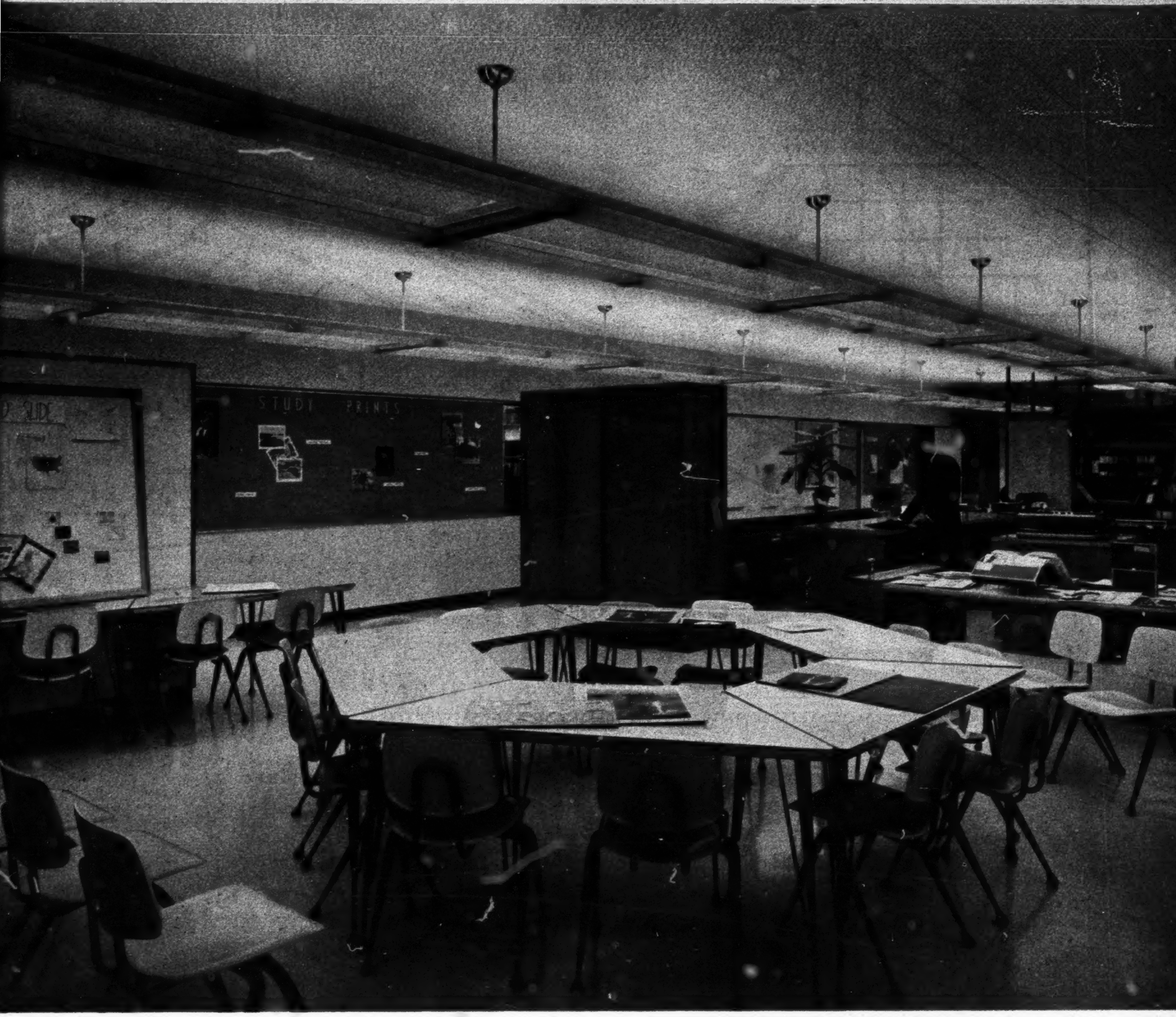


DIRECT-INDIRECT OR GENERAL DIFFUSE FLUORESCENT FIXTURE

Forty to sixty per cent of the light is directed downward at angles below the horizontal. The major portion of the illumination produced on ordinary working planes is a result of the light coming directly from the luminaire. There is, however, a substantial portion of the light directed to the ceiling and side walls. Where these are light in color, the upward light provides a brighter background against which to view the luminaire, in addition to supplying a substantial indirect component which adds materially to the diffuse character of the illumination.

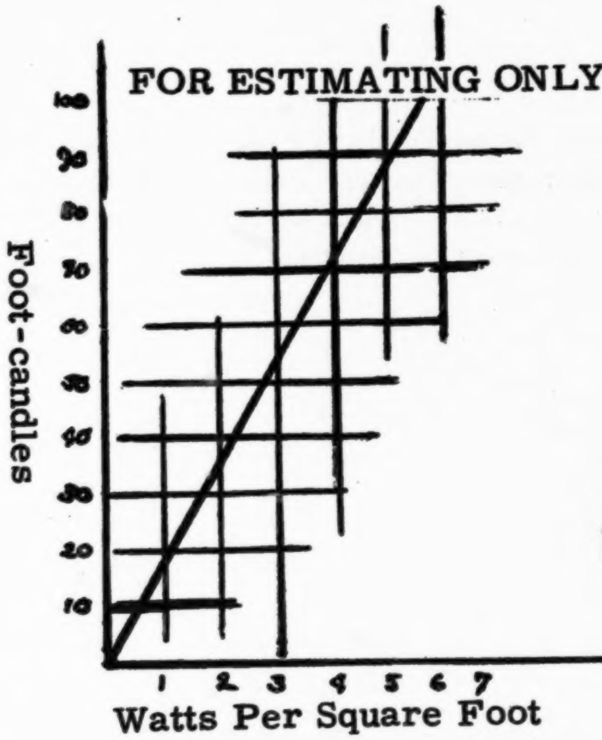
Fixtures should be mounted in continuous rows, suspended from the ceiling a minimum of 8 inches. Spacing between rows should not exceed 1.25 times the mounting height. Maximum spacing from wall to first row of fixtures equals one-half the spacing between rows. Fixture rows should run parallel to and not more than 4'0" from chalkboards unless supplementary chalkboard lighting is used.

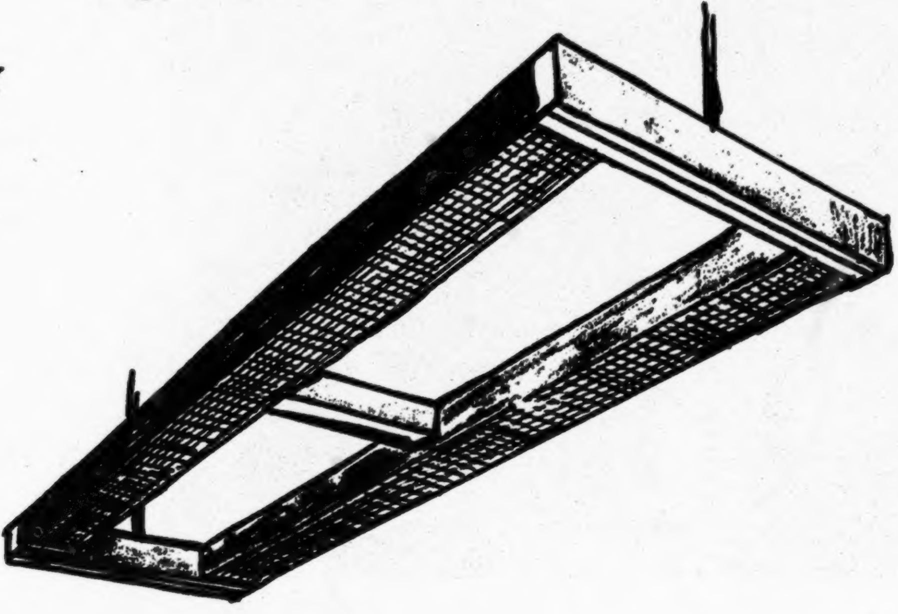
Fixtures must be shielded by means of louvers to conform to maximum brightnesses set out in Table V.


SLIDE
STUDY PRINTS

THE FLEXIBILITY IN FURNITURE ARRANGEMENT AND USE PROVIDED BY THESE TRAPEZOIDAL TABLES REQUIRES SUITABLE LIGHTING OVER THE ENTIRE WORK SPACE AVAILABLE.

Figure No. 3





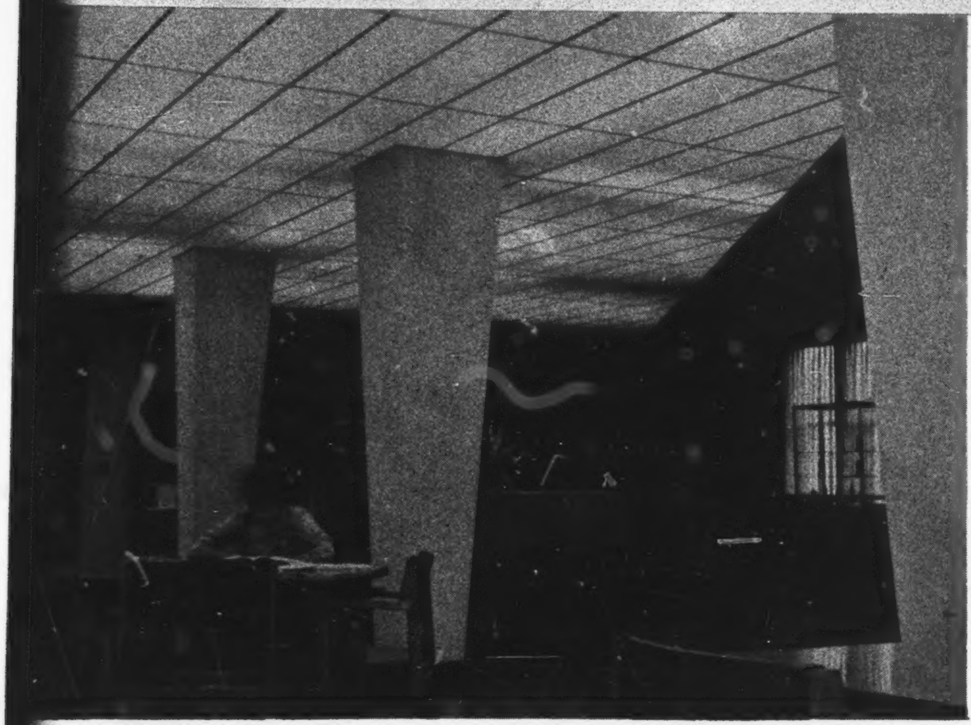
LUMINOUS-INDIRECT FLUORESCENT FIXTURES

Ninety to 100 per cent of the light output of the luminaire is directed toward the ceiling at angles above the horizontal. Practically all of the light effective at the working plane is redirected downward by the ceiling and to a lesser extent by the side walls. Since the ceiling is in effect the light source, the illumination produced is quite diffuse in character. While indirect lighting is not as efficient as some of the other systems on a purely quantitative basis, the even distribution and absence of shadows and reflected glare frequently make it the most desirable type of installation for schools. Because room finishes play such an important part in redirecting the light, it is particularly important that they be as light in color as possible, and carefully maintained in good condition. The ceilings should always have a matte (dull) finish, if reflected images of the light source are to be avoided.

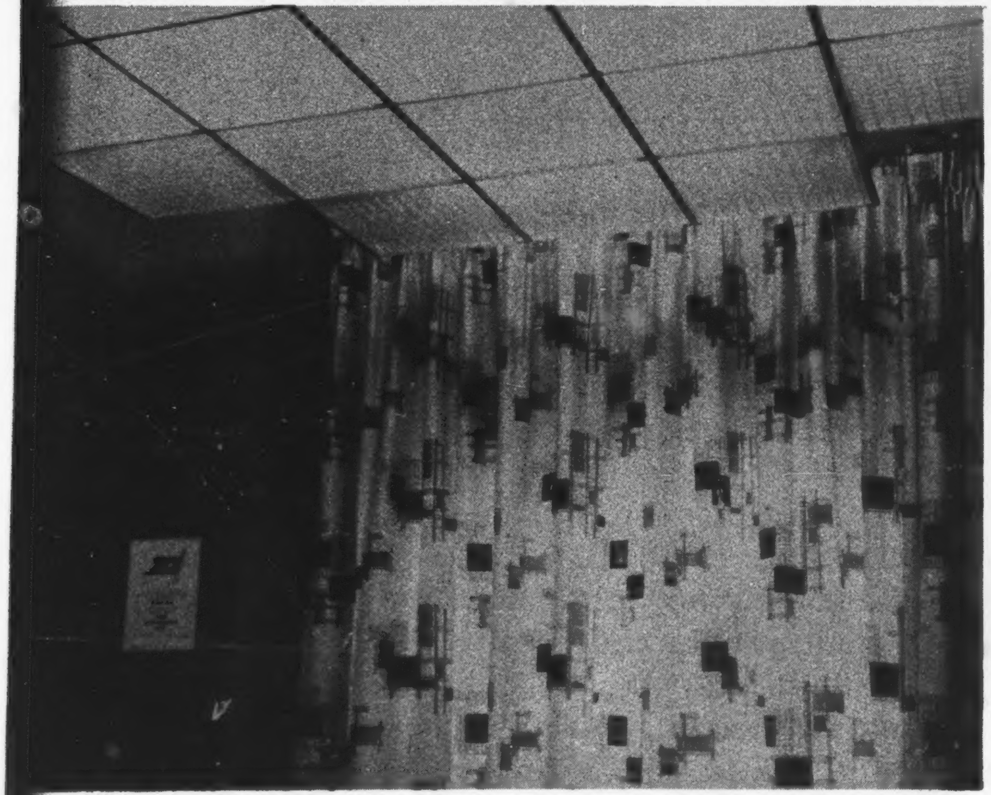
Glass or plastic luminaires in this classification are known as "luminous indirect", while metal luminaires which transmit no light are totally indirect. The translucent type is sometimes more desirable than the totally indirect because a luminous fixture is less sharply silhouetted against the relatively bright ceiling.

Fixtures should be mounted in continuous rows suspended 12" minimum from ceiling.

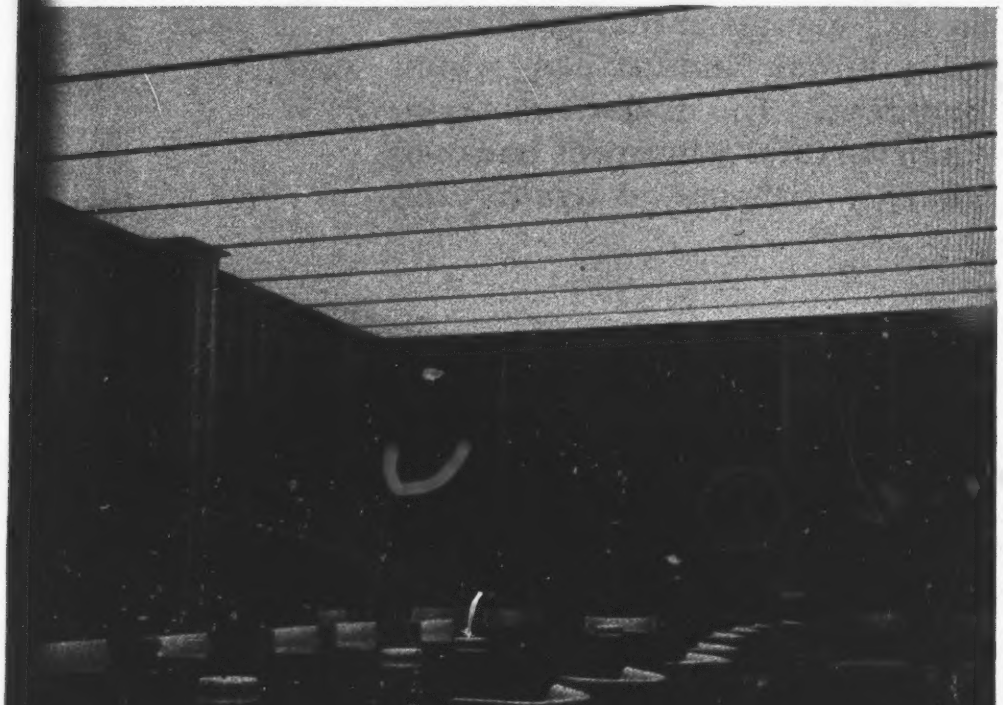
Maximum spacing between rows should not exceed 1.3 times the mounting height. Maximum spacing between wall and fixtures should not exceed one-half spacing between rows.



MANY POTENTIAL LIGHTING PROBLEMS IN THIS ROOM—PILLERS AND CUT OUT AREAS—ARE SOLVED SATISFACTORILY BY THE TRANS-LIGHTED CONCEPT.

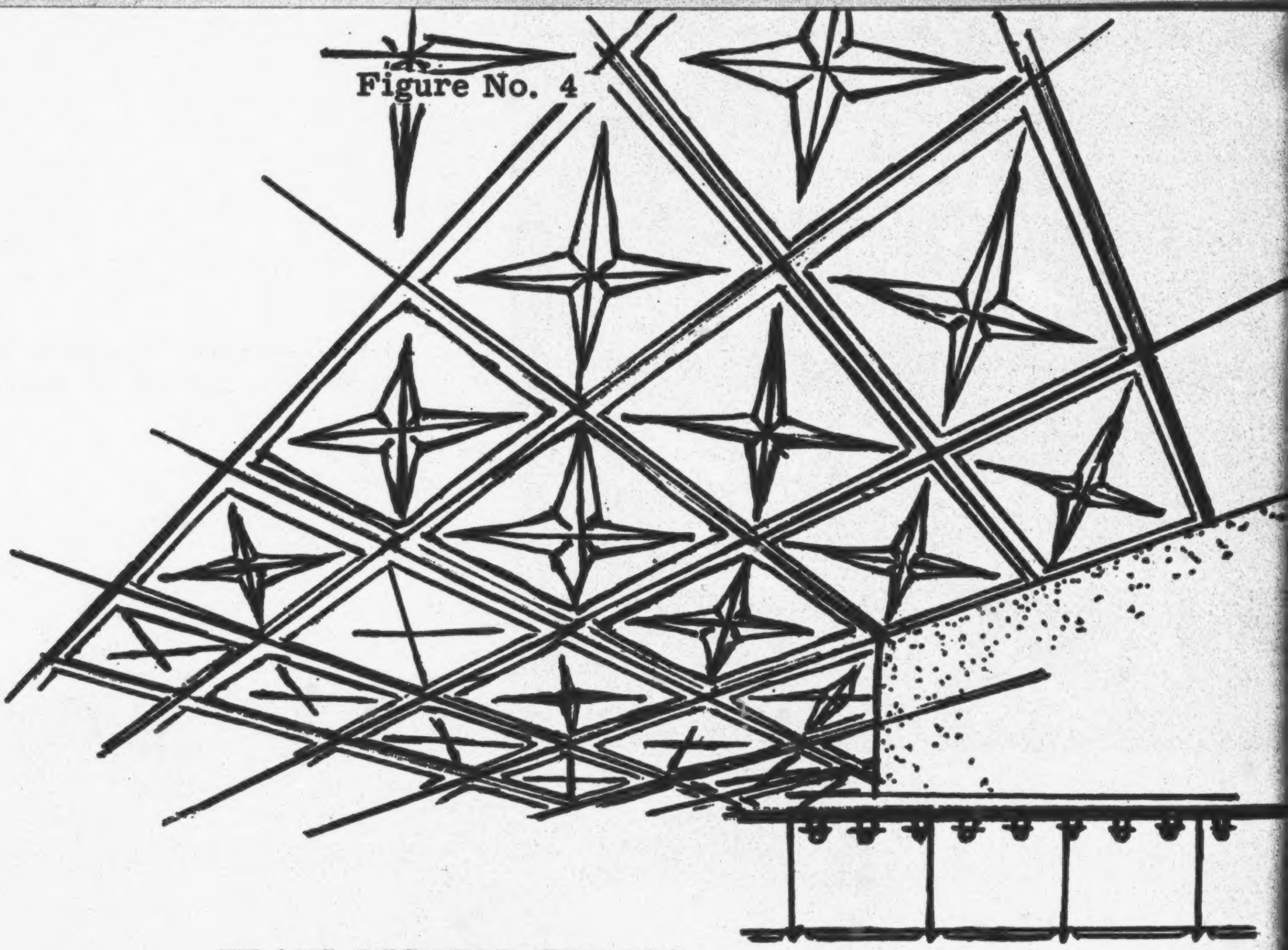


THIS CLOSEUP SHOWS DETAILS OF THE TRANSLUCENT METAL LOUVERS USED WITH THIS METHOD OF LIGHTING.



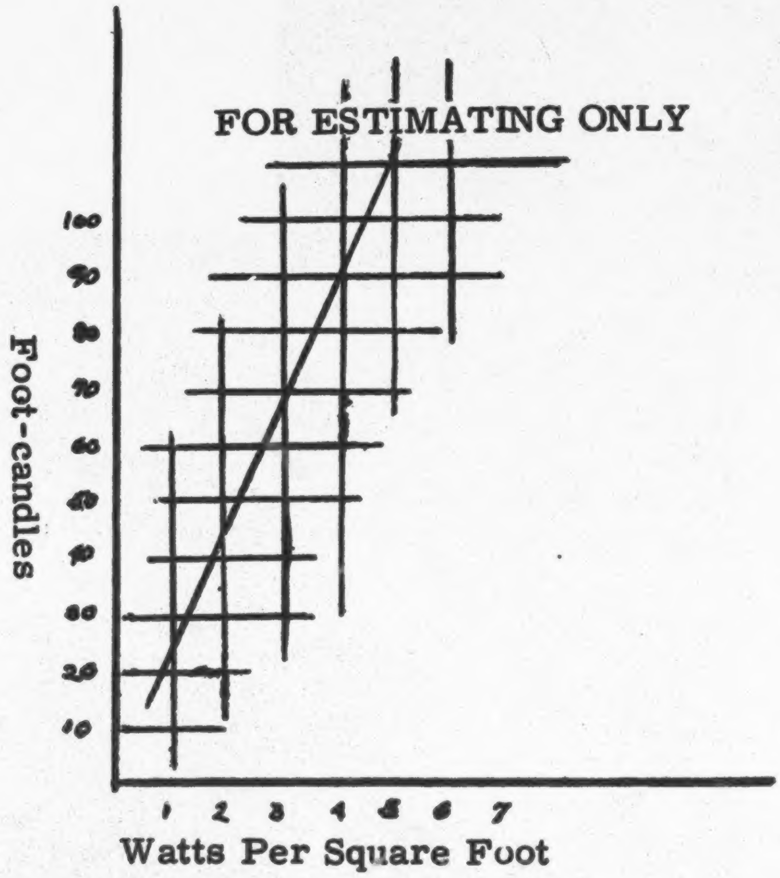
A WINDOWLESS CONFERENCE ROOM EMPLOYS A TRANS-LIGHTED CEILING TO ADVANTAGE.

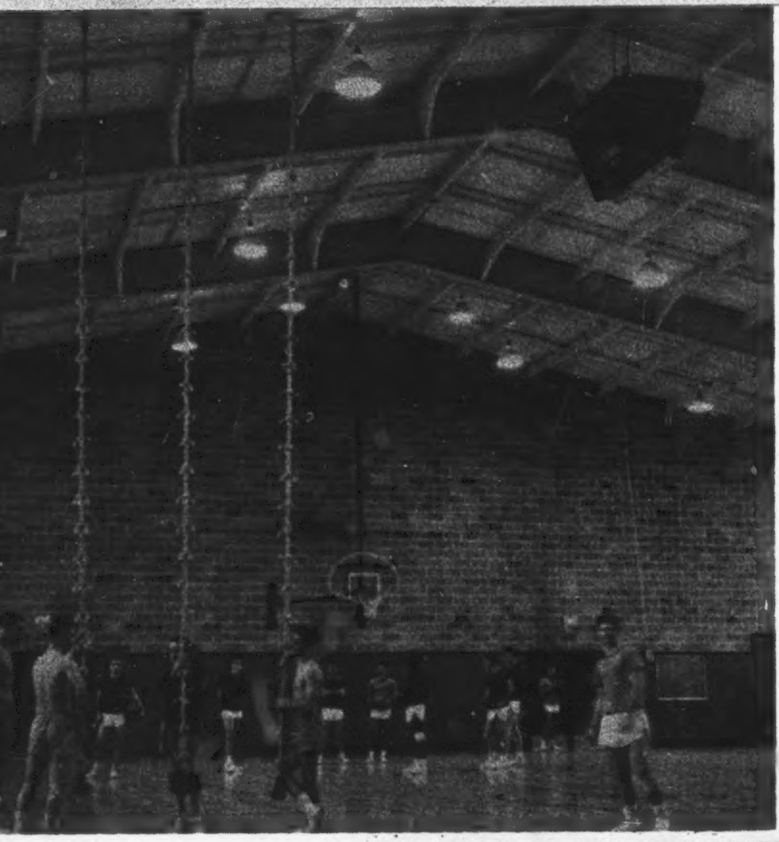
Figure No. 4



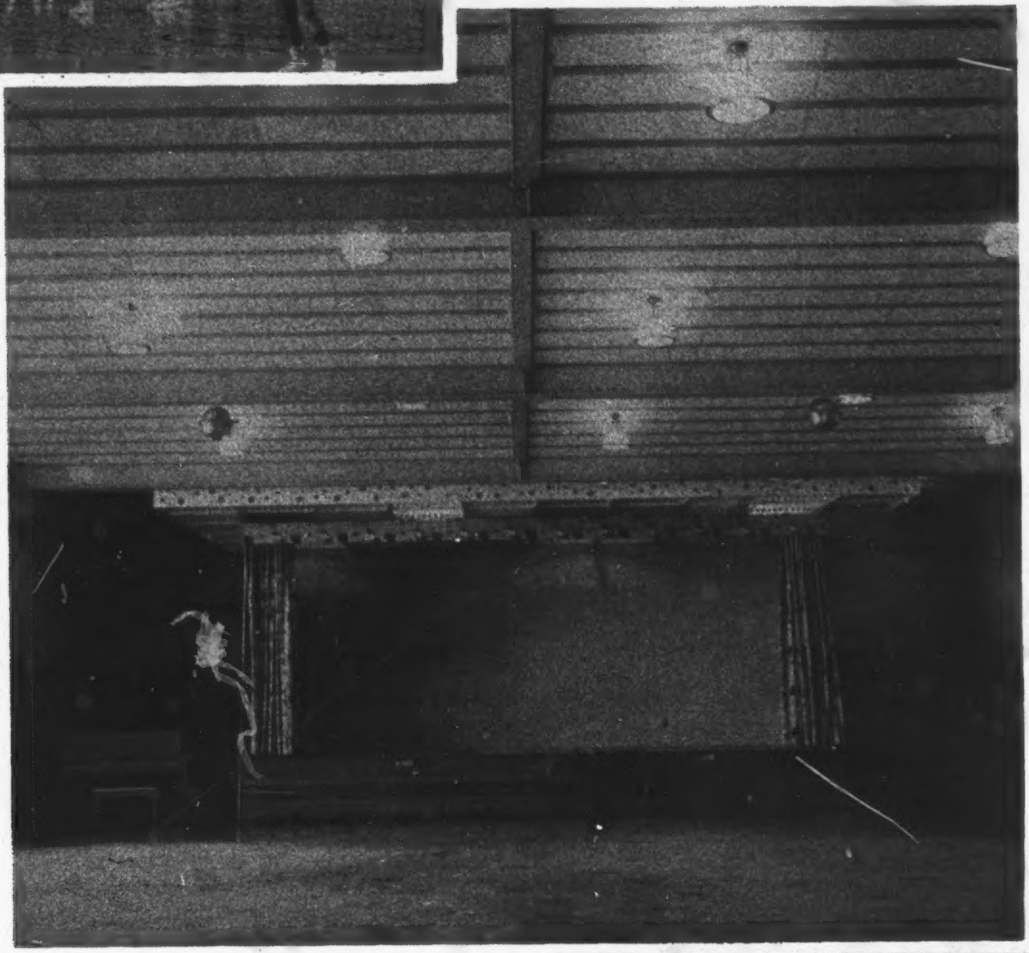
TRANS-LIGHTED CEILING

Translucent glass or plastic panels, or metal or plastic louvers with fluorescent lighting installed above, creates a highly diffused source of lighting. A minimum of shadows are created since light comes from every direction of the ceiling. A very satisfactory method of achieving high intensities of lighting within acceptable brightnesses.





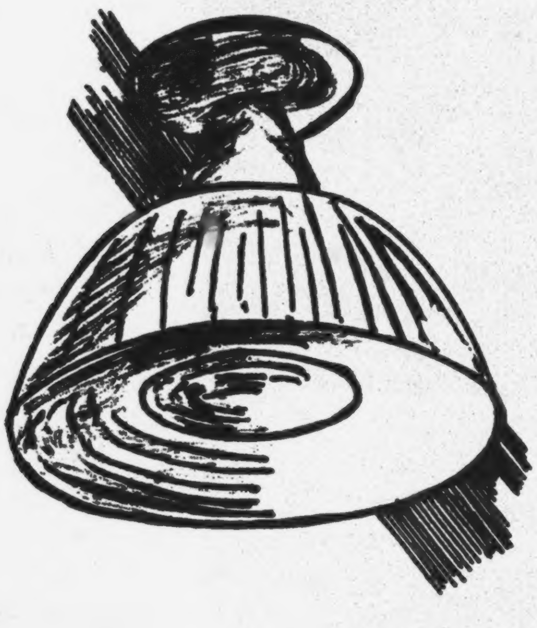
THESE CEILING FIXTURES SUCCESSFULLY ILLUMINATE THE ENTIRE PLAYING FLOOR.



AN ALTERNATING ARRANGEMENT OF LIGHTS IS USED FOR THIS ELEMENTARY ALL-PURPOSE ROOM.

THIS OVERALL VIEW OF A SCHOOL LUNCH ROOM SHOWS AN UNUSUAL USE OF MULTIPLE LIGHT FIXTURES. THE LIGHTS ALSO HARMONIZE WITH THE ROOM COLORS.

Figure No. 5

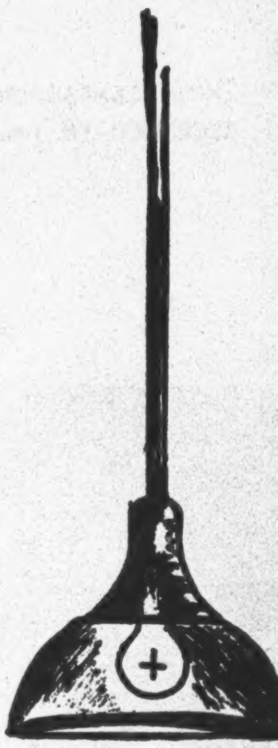


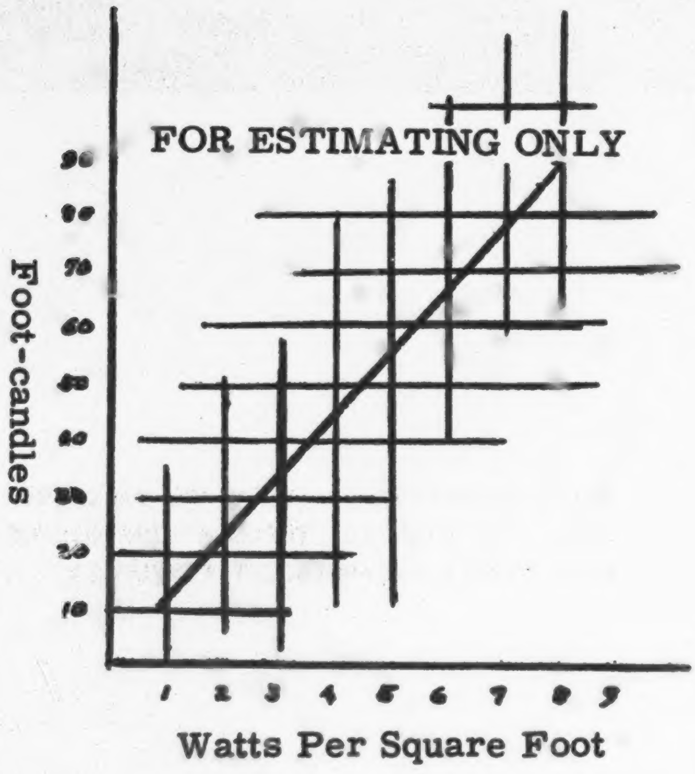
SEMI-DIRECT INCANDESCENT FIXTURE

Brightness limitations set forth previously dictate a prismatic refractor not to be confused with plain, frosted, or opal glass, or plastic shielding elements.

More efficient than indirect incandescent, consequently, higher lighting levels may be attained with less heat.

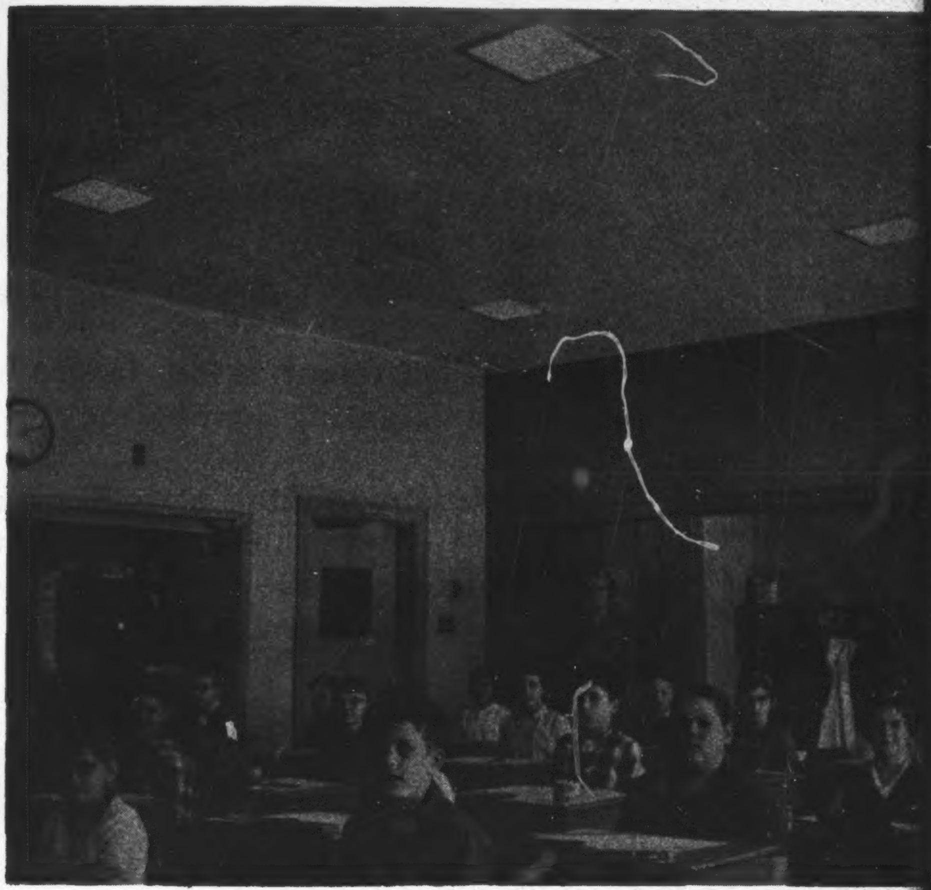
Maximum spacing should not exceed 1.0 times the mounting height. Maximum spacing between wall and fixtures should not exceed one-half spacing between rows.





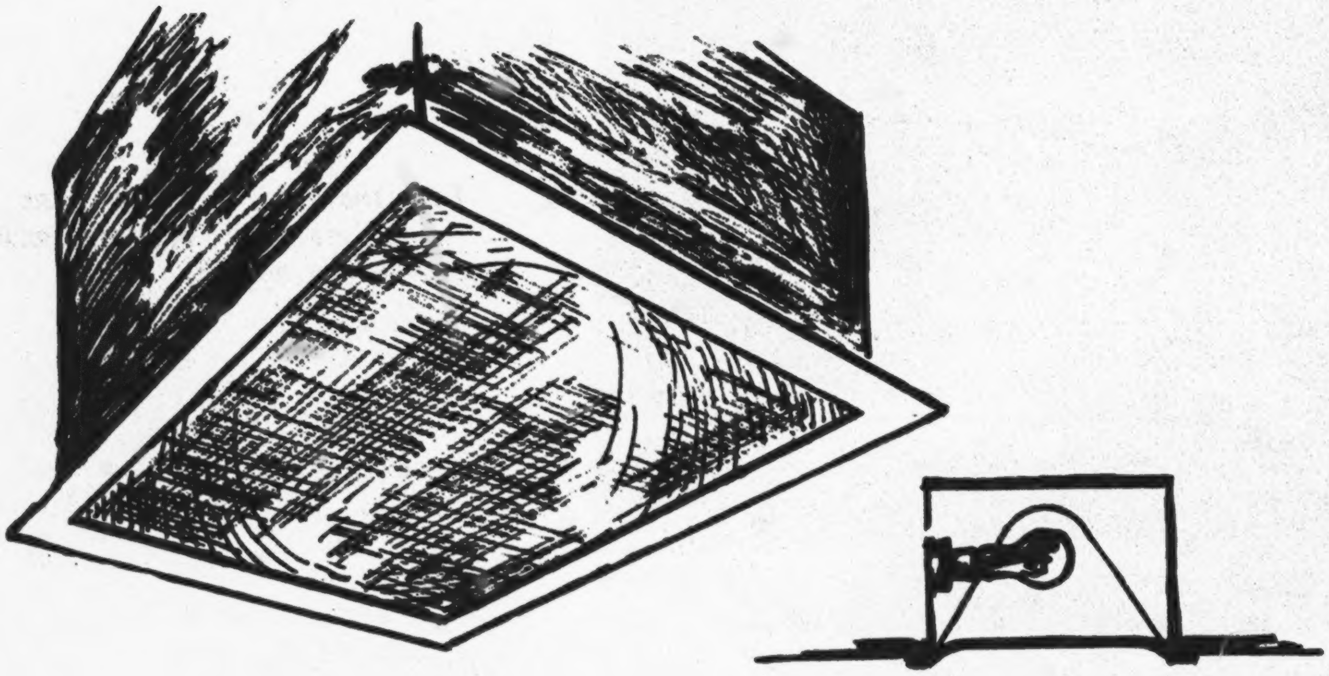
A WELL-LIGHTED SWIMMING POOL PROVIDES PLEASANT AND SAFE ATHLETIC OPPORTUNITIES.

THESE CLASSROOM LIGHTING FIXTURES ARE RECESSED IN THE CEILING.



THIS WINDOWLESS KITCHEN AND CAFETERIA AREA IS LIGHTED THROUGH THE USE OF MANY DIRECT INCANDESCENT FIXTURES.

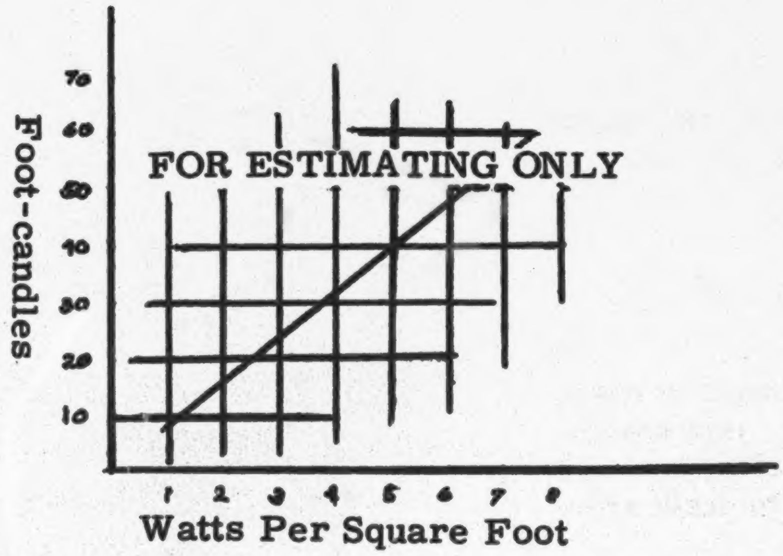
Figure No. 6



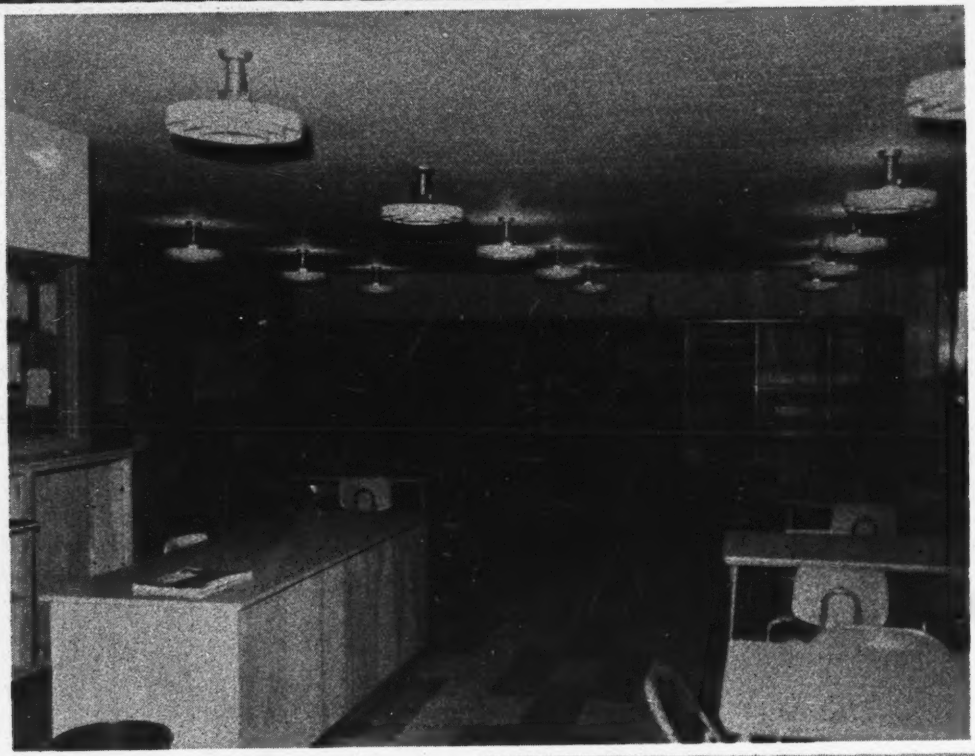
DIRECT INCANDESCENT FIXTURES

Recessed type with a low brightness prismatic lens using a 300 watt lamp. Maximum spacing between fixtures should not exceed 1.0 times the mounting height. Spacing from wall to nearest row of fixtures should not exceed one-half fixture spacing.

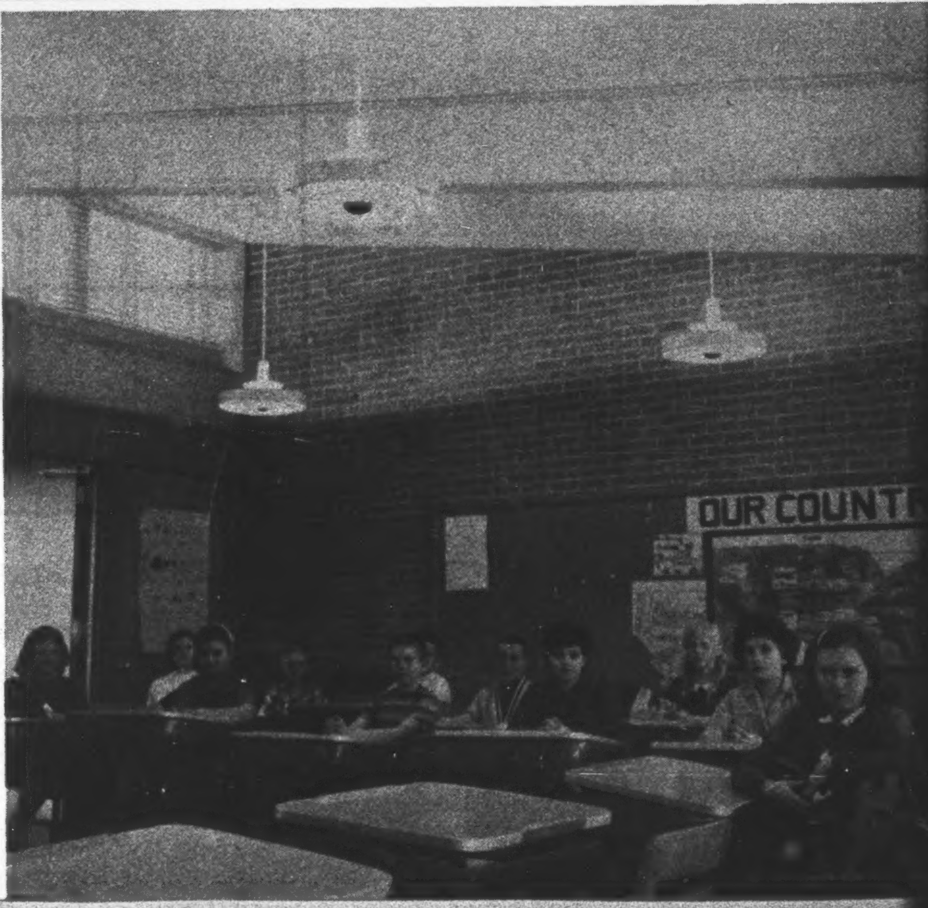
When using a fixture of this type, ceiling brightness depends upon reflection from the floor. It is essential to use the higher reflection factor as set out in Table I.



THE INDIRECT FIXTURES ARE USED TO LIGHT DIFFERENT PROJECT AREAS IN THIS ELEMENTARY ROOM.

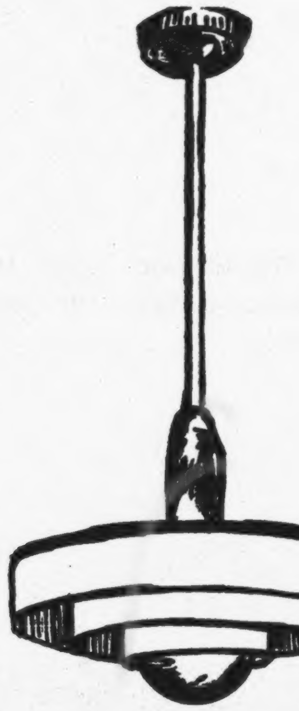


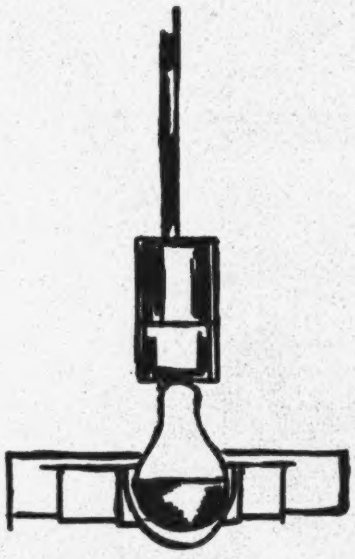
THIS PICTURE ILLUSTRATES THE PROPER DISTANCE BETWEEN ROWS OF LIGHTING FIXTURES.



DIFFERENT SUSPENSION LENGTHS OF THESE INDIRECT FIXTURES TAKE INTO CONSIDERATION THE SLOPING CEILING. THESE FIXTURES WORK WELL WITH CLEAR STORY WINDOWS.

Table No. 7



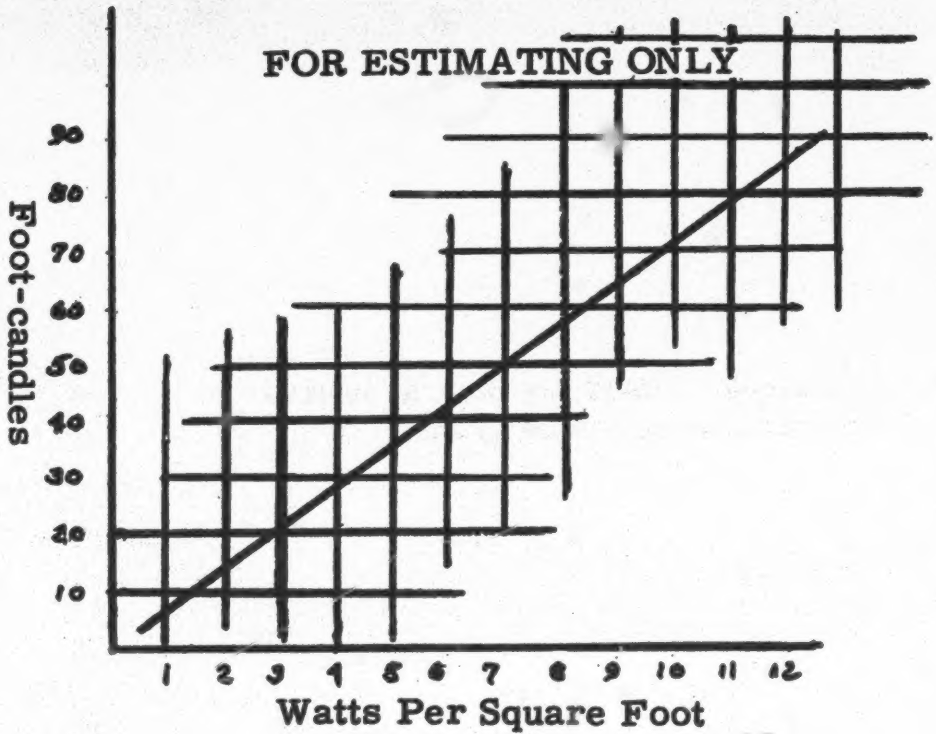


INDIRECT INCANDESCENT FIXTURES

Usually a 500 watt silvered bowl lamp shielded by concentric ring louvers. Fixtures should be pendant mounted. Maximum spacing between fixtures—1.25 times ceiling height; maximum spacing between wall and fixtures—one-half times spacing.

This lighting has same qualities as listed for luminous indirect fluorescent fixtures. Beware of excessive heat and ceiling brightness from higher levels of lighting with this type fixture. **Quantity of lighting will fall off rapidly as ceiling darkens due to soil and age.**

Fixtures made of processed aluminum will usually maintain higher efficiency throughout life.



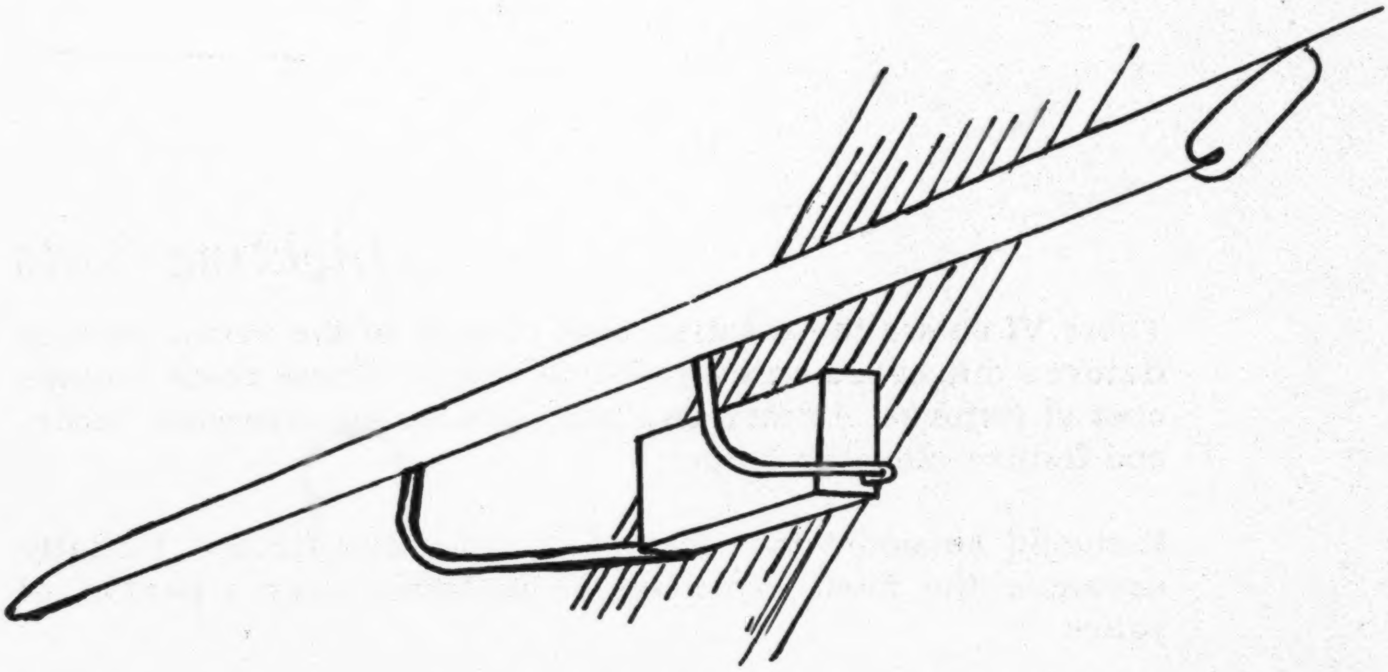
THIS PICTURE SHOWS THE METHOD USED IN MOUNTING THE CHALKBOARD LIGHT, AND THE TYPE OF MOUNTING USED.

Green Chalkboards
illuminated by

THE ENTIRE CHALKBOARD IS VISIBLE FROM ALL SECTIONS OF THE ROOM, WITH NO GLARE OR SHADOWS.

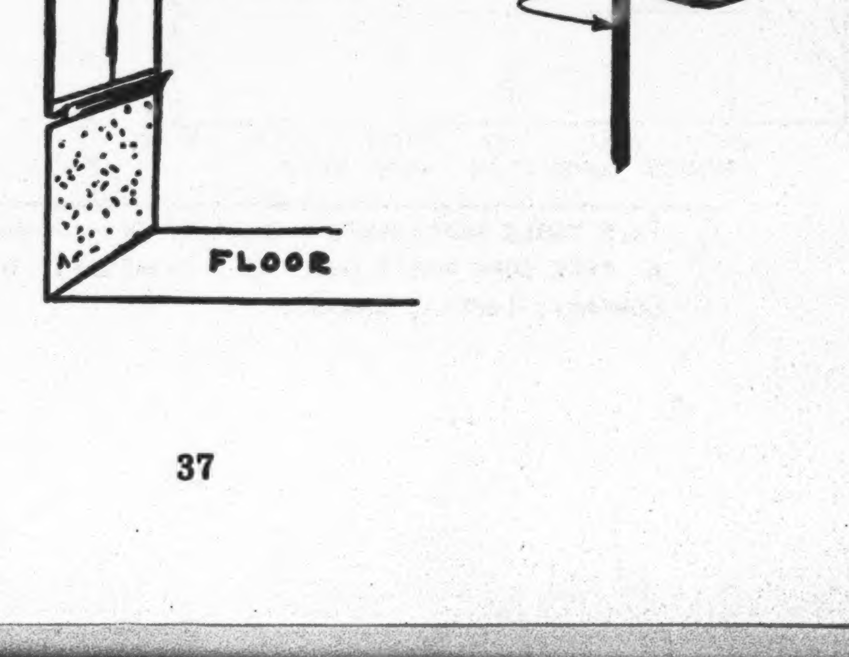
CHALKBOARD LIGHTS ARE USED TO SUPPLEMENT REGULAR CLASSROOM LIGHTS.

Figure No. 8



FLUORESCENT CHALKBOARD LUMINAIRE

Two-lamp (parallel) T-12 fluorescent fixtures wall mounted in a continuous row over the chalkboard. With an asymmetric reflector this unit will provide 65-90 foot-candles to supplement general room lighting.



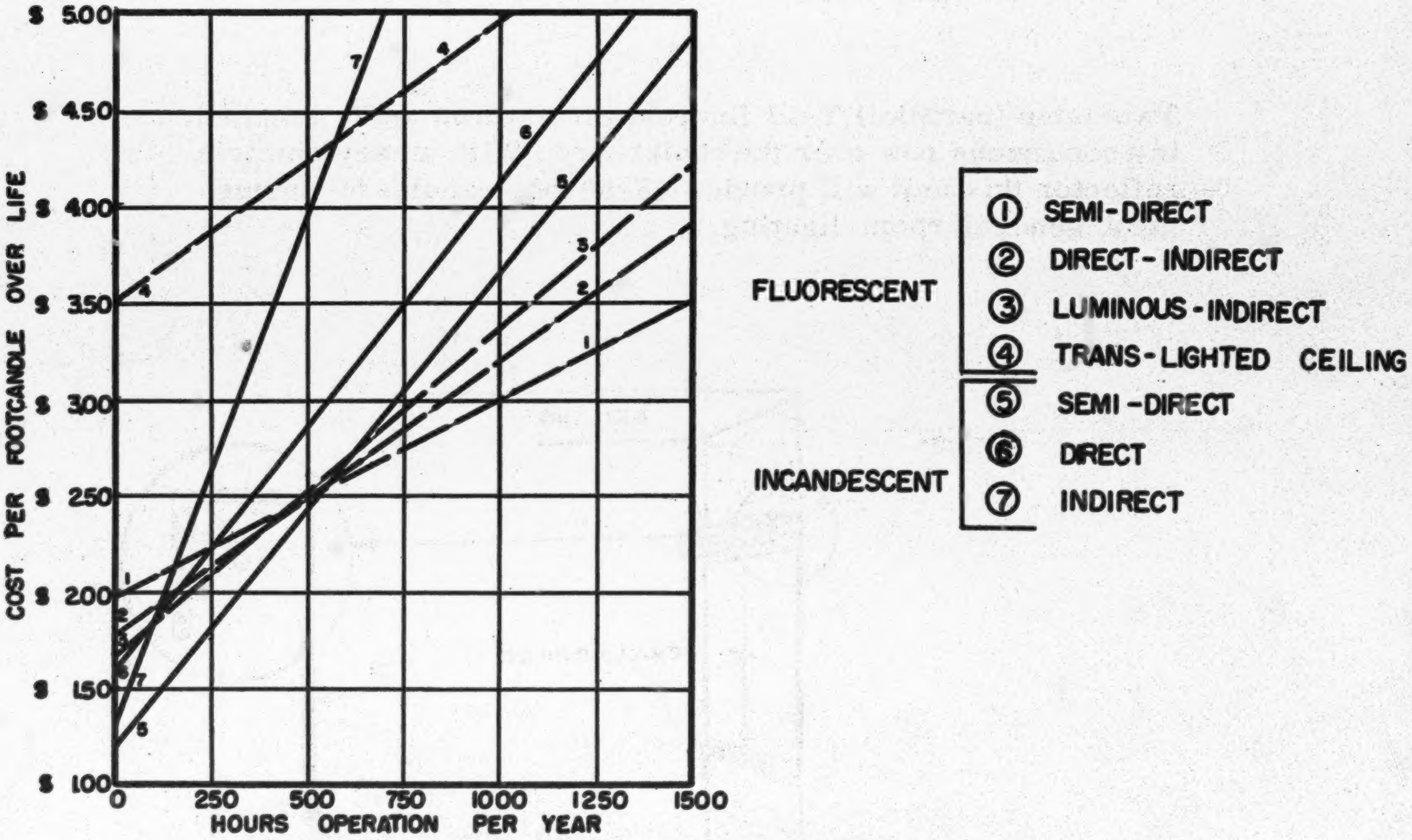
Lighting Costs

Table VI shows the relative cost of each of the seven lighting fixtures discussed on the previous pages. These costs include cost of fixtures, electricity, lamps, lamp replacement labor, and fixture cleaning labor.

It should be noted that the least expensive fixture initially becomes the most expensive to maintain over a period of years.

TABLE VI

TOTAL COST PER FOOT-CANDLE OVER LIFE OF FIXTURES[1]



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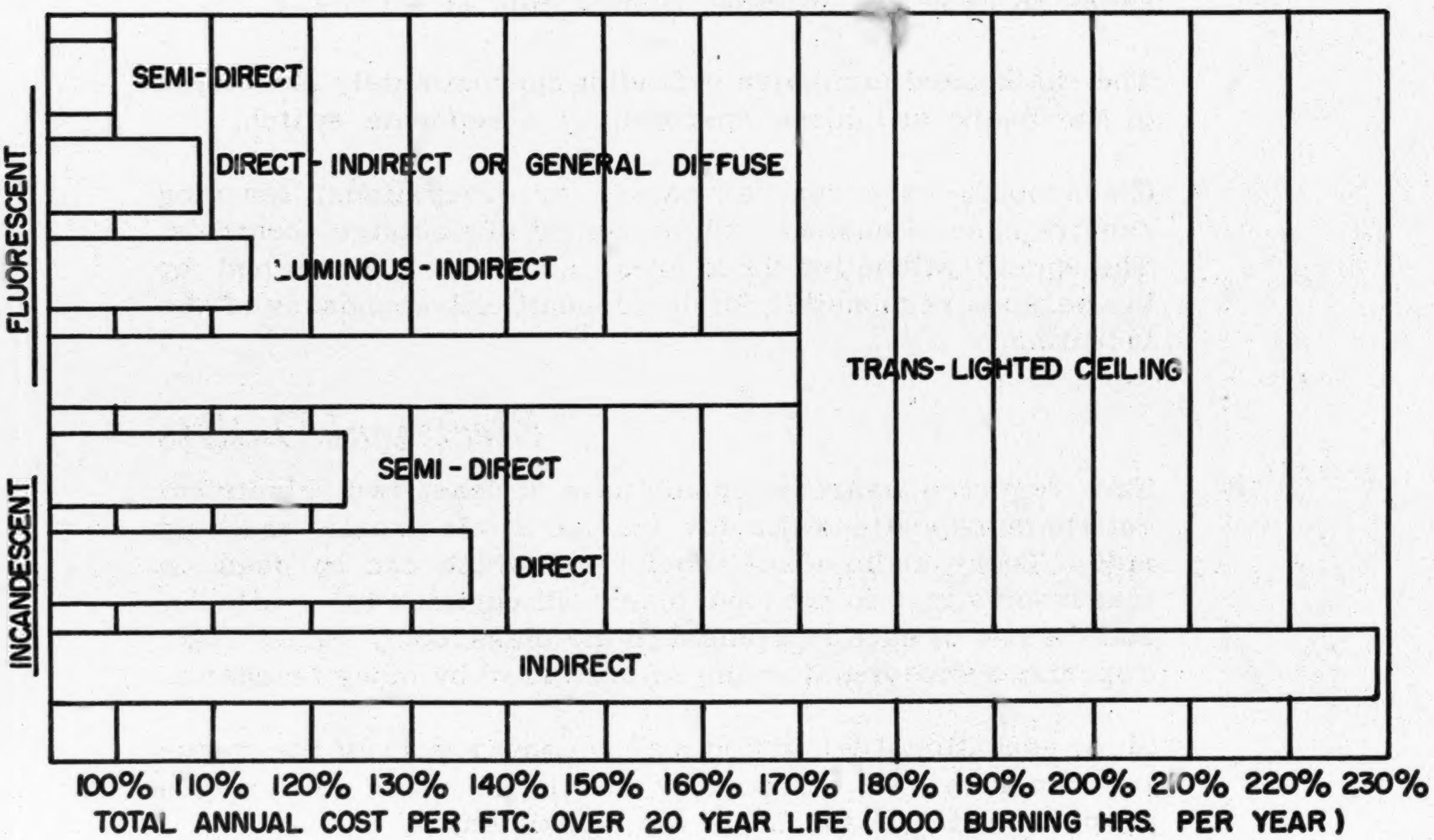
[1] This table represents a summary of a complete cost analysis. For a free copy write Neil J. Thompson, The Kansas Power and Light Company, Topeka, Kansas.

Table VII shows the relative annual cost per foot-candle over a 20-year life assuming the lights are operated 1,000 hours per year.

TABLE VII

COST PER FOOT-CANDLE OVER A 20-YEAR LIFE[1]



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[1] This table is a summary of a complete cost analysis, by Neil J. Thompson, Kansas Power and Light Company, 800 Kansas Avenue, Topeka, Kansas.

Light Switches

The number of light switches should be determined by the lighting arrangement of each room. It is desirable to install light fixtures in rows arranged properly to avoid dark spots. Usually a regular classroom will necessitate at least three or more rows of lights. Each row should have a separate light switch located by the door, thus enabling the use of any one row of lights separately or in groups as needed in order to provide sufficient illumination at all times.

The chalkboard luminaire extending approximately the length of the board should be operated by a separate switch.

Classrooms used for laboratory or occupational teaching require special number and placement of electrical controls. The specifications for these areas should be determined by the persons responsible for the educational soundness of the facilities.

Electrical Outlets

Each regular classroom should have at least two electrical outlets on opposite walls for the use of electronic teaching aids. Today audio-visual equipment which can be used in classrooms that do not have black-out curtains is available, and the use of such equipment in the classroom, rather than a special audio-visual room, is preferred by many teachers.

Since educational television may become a part of the regular program, all classrooms should be wired to provide proper electrical facilities for television.

Rooms for special teaching areas, such as science, homemaking, commerce, art, shop and related subjects require a sufficient number of additional well-placed outlets.

Maintenance of Light Fixtures

There are some school plants which are not receiving the maximum benefits from their lighting installation because of

a poor lighting maintenance program. All lighting equipment should be cleaned thoroughly at least twice a year, more often if the rooms are in a dusty location. Fixtures should be washed with warm detergent water and rinsed thoroughly with clean water. If fixtures are allowed to air dry instead of being wiped dry with a cloth, they will remain clean longer.

In designing for good visual environment, lighting engineers have established 70 per cent as being an average reflectance factor on a horizontal working surface for the normal classroom area. In designing for a given foot-candle level, it is necessary to consider that the efficiency of the lighting equipment will drop because of the collection of dust and dirt between cleaning periods and that lamp efficiency does drop with length of life. Under normal conditions, this loss will be approximately 30 per cent.

Fluorescent lamps are rated as having a normal life of 7,500 hours, which would indicate that they would last about five years under average school conditions. Fluorescent lamps lose efficiency as they are used and it is recommended that they be replaced before the light output drops to the point where it is below the desired level. It is suggested that the tubes or lamps be replaced after about six thousand hours or an average of four years of use. In most fluorescent fixtures, when one lamp burns out, the ballast operates in an unbalanced condition and the life of the ballast is shortened. Therefore, it is recommended that burned-out lamps be replaced immediately.

Incandescent lamps have an established lamp life of 750-1000 hours for general lighting purposes. Lamp replacement in an incandescent unit is usually a simple matter since there are no other devices such as ballast or starter switches to cause trouble.

Lighting Surveys

A good lighting survey consists of measuring the quantity of foot-candles and evaluating the quality of the light. This service is available from the State Department of Public Instruction. Inasmuch as the State Department of Public

Instruction is the only agency authorized by law to accredit elementary and secondary schools, it is suggested that findings of school lighting surveys made by other agencies or school lighting consultants be submitted by the school boards to the State Department of Public Instruction for review and approval. Foot-candle meters should be used to measure the quantity on both bright and cloudy days. If, on dull days, the natural light plus the existing artificial lighting system does not provide the minimum required foot-candles of light through **all** areas of the room at desk top level, there is need for more artificial light.

When fixtures are of poor design, or when there are no provisions for shielding bare bulbs or tubes, increasing the amount of light may do more harm than good. In either case, lighting efficiency and visual comfort in the room can be attained only if suitable fixtures, with sufficient light output and proper shielding, are installed. (See Table IV.)

It is highly recommended that school boards and administrators seek the assistance and services of trained and registered architects or lighting engineers to design and plan any major school relighting program.

> "Lighting is by no means simply a matter of cost, but rather a matter of interest and technological know-how. Many poor lighting jobs cost more than a good job would have cost."
>
> — Charles D. Gibson
> Chief, Bureau of School Planning
> State of California

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